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ELIGUG STACKS, NEAR PEMBROKE. [*Frontispiece.*

RECORDS OF THE ROCKS;

OR,

NOTES ON THE GEOLOGY, NATURAL HISTORY, AND ANTIQUITIES

OF

NORTH & SOUTH WALES, DEVON, & CORNWALL.

By Rev. W. S. SYMONDS, F.G.S.,

RECTOR OF PENDOCK.

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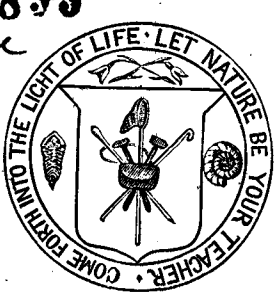

WITH NUMEROUS ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1872.

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TO

SIR CHARLES LYELL, BART., F.R.S., F.G.S.,

I Dedicate

THESE

RECORDS OF THE ROCKS,

AS A SLIGHT ACKNOWLEDGMENT OF THE ADVANTAGES I HAVE RECEIVED THROUGH THE STUDY OF HIS WORKS,

WHICH HAVE BEEN MY MENTORS FOR NEARLY THIRTY YEARS,

AND OF THE VALUE AT WHICH I ESTEEM HIS FRIENDSHIP.

W. S. SYMONDS.

PENDOCK, 1872.

PREFACE.

THIS Work is the result of an accumulation of Notes on Natural History, stored during several years when travelling, on Geological expeditions, throughout the districts on which it treats. It is written for Amateurs who, like myself, enjoy passing their leisure hours among Rocks, old Castles, old Authors, and the wild flowers of strange wayside places. It does not assume to be a strictly scientific description of the Geological structure of the different tracts of country to which it alludes, but I trust it is correct as far as it goes.

For thirty years I have been a lover and constant explorer of the Geology of the districts to which this Volume relates; and having also had more than usual opportunities of making observations on the Archæology and Natural History, I have dealt with some districts to which Murchison hardly alludes, and with subjects that would have been foreign to his purpose.

The "Grey stone rests above the Chief," and I may now venture to say that which, if I had penned it before, would, by the world, have been deemed flattery; and I say it as one who probably is more intimate with the "Silurian System," and Siluria, than any living Amateur.

It is this:—let the Geologist of succeeding years, who is supplied with all the Maps, Sections, and other appurtenances furnished by Geological Surveyors and professional experience, bear in mind that the *grauwacke* of Siluria was reduced to order, out of chaos, by Murchison; and how, by the publication of the "Silurian System," he advanced the Science of Geology to an extent that other generations will probably comprehend better than the present seems capable of doing.

The Volume is enriched by sketches of scenery from the pencil of my friend, and frequently my companion, Sir William Guise, Bart., and by the reproduction of many plates of landscapes, fossils, and sections from that well-known scientific work, "Siluria," by Sir Roderick Murchison.

I have to render my thanks to Miss Dora Baker, of Hasfield Court, Gloucestershire, for illustrations of some of the typical Fossils; and last, though not least, to Miss Roberts, of Hazeldine, Red Marley, for efficient aid in carrying the MSS. through the press, and for the copious Index.

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RECORDS OF THE ROCKS.

CHAPTER I.

INTRODUCTION.

Introductory Remarks—Astronomy of the Ancients—Astronomical and Chemical Researches respecting the Earlier Stages of the Earth—Application of Optics to Chemistry by Spectrum Analysis—Opinions of the Chemist and Microscopist on the subject of Materials of the Earth's Interior—Volcanic and Plutonic Rocks—Earthquake Action—Elevation of Land since the Glacial Period—Ceaseless Change.

DURING the last century Science has advanced with extraordinary strides, and has assumed, in consequence, the utmost importance in the minds of men. In earlier times its progress was comparatively slow, and it is not difficult for the reader of History to trace the causes of non-development in the desolation of barbaric warfare, the dark clouds of ignorance, and the curse of superstition, and religious persecution, which for ages hung over the whole of Europe. In these later and less troubled times, aided by the freedom now extended to thought and scientific discovery, various branches of Philosophy march on with surer and steadier footsteps.

And of no branch of Science can this be more truly said than of Geology. The question of the creation, or origin, and the development of the Earth, is a subject which must ever be of the greatest interest to God's intellectual creature—Man. And although there are many problems with which we are at present utterly at a loss how to deal, and many mysteries which we have not as yet penetrated, yet, looking upon all that has been

added to our knowledge by the patient investigations of those who have devoted a lifetime to geological research, we must allow that immense progress has of late years been made in acquiring knowledge with respect to the bygone history of this Planet.

The Science of Geology has conjured new forms of Life into existence, and to him who reads the Records of the Rocks there is unfolded a history such as the inventor of fairy tales never dreamed of, and which almost startles us sometimes by the strangeness of its revelations. By the aid of these records we can trace certain changes the Earth has undergone during innumerable epochs when as a world she has revolved in space, and during which, as far as we can learn, her Life systems have been progressing with time and development.

The Records of the Rocks reveal to us that in the history of creation the lower animals preceded the higher; the protozoa, mollusca, and crustacea preceded the fish; the fish preceded the reptile; the reptile preceded the bird; the bird preceded the higher mammalia; and man did not appear upon the scene until long after many of the inferior animals had passed away for ever.

Palæontology, or the study of fossil Animals, requires much time and attention, and is hardly within the reach of an amateur who is distant from museums and libraries. Still, anyone may become acquainted with what may be termed the typical fossils of the various formations through good books and country collections, and this knowledge will suffice for a commencement, at all events, in the study of Physical Geology. Physical Geology is open to everyone who is blessed with physical powers and mental activity, and it takes the lover of Nature among sea-cliffs, and shores; mountains and vales; active and extinct volcanoes; lava currents, recent, and old; by the glaciers of the Alps, and the extinct glaciers of mountains now no longer capped even with snow; by silted-up lakes, and lakes now dammed by moraines whose ice is gone; among furrowed hillsides, and glaciated glens. It is a glorious history this same Physical Geology, with its records of sea beds elevated into

mountains, and its mountains lowered beneath the sea. In the following pages I have endeavoured to render some information respecting localities where such phenomena may best be seen and visited.

The conclusions arrived at of late years through chemical and astronomical researches, respecting the earlier stages of the planet we inhabit, are so remarkable when compared with former views entertained on the subject, that it may be worth while to allude to what may be termed the Astronomy of the Earth before alluding to the history of earthquakes, earthquake action, and volcanic action in connection with her geology. Those who examine the records gathered respecting the knowledge of Astronomy among the ancients, collected by Sir George Cornewall Lewis, and Delambre, will feel convinced that man, in the earliest historic periods, possessed no real knowledge of the Solar System. This Planet—our Earth—was supposed to be the central orb round which the Sun revolved daily. The firmament is represented by Hebrew and Greek writers as a massive, solid substance, with windows or openings in it through which the rain descended and the floods came.

The earliest records respecting certain of the Fixed Stars is that contained in the Book of Job, where he speaks of the Almighty who "alone spreadeth out the heavens and treadeth upon the waves of the sea; which maketh Arcturus, Orion, and Pleiades, and the chambers of the south."

In the days of Hesiod and Homer (about 900 years B.C.) the annual motion of the stars, with respect to their rising and setting, is chronicled; nevertheless those cultivated Greeks conceived of the sun as a divine charioteer, who drove his fiery steeds over the steeps of heaven until he bathed them in the western waves.

Thales, who lived about 600 B.C., is the earliest philosopher with whom we can connect the pursuit of astronomy in Greece, and we find him calculating and predicting an eclipse of the Sun, which we learn from the Astronomer Royal came to pass on the 28th May, 585 B.C.

Pythagoras taught that the earth is not motionless in the

centre of the universe, but moved in an orbit through space; and Philolaus, the contemporary of Socrates, and Democritus, committed the Pythagorean doctrines to writing, but the progress of astronomy was crushed out for a time by the religious persecution and death of Socrates.

Empedocles (B.C. 450) maintained the motion of the planets, although he thought that the fixed stars were riveted in a crystal heaven; and the knowledge of astronomy was slowly developed, step by step, by the discoveries of Hipparchus (160 B.C.), and by Ptolemy (160 A.D.), until, in the sixteenth century, the Copernican system established astronomy as an experimental science.

The laws of the planetary motions had been ascertained by Kepler, and Tycho Brahe, when the revelations of the telescope burst upon Galileo (A.D. 1609), and he beheld the moons of Jupiter illuminating their planet and undergoing eclipses in his shadow. To him also were first revealed the crescent phases of Venus, and a glimmering of the marvels of the planet Saturn, an enormous world lighted by no less than eight moons, and enveloped with splendid luminous rings.

The grand Newtonian discovery of the Law of Gravitation followed; a law now known to extend throughout the remotest universe; the law by which satellites revolve around their planets, and by which our Sun, the centre of a vast system, revolves, with all his host of planets, satellites, asteroids, comets, meteors, and meteorites, round a common centre, as our moon revolves round our earth.

Notwithstanding these discoveries, until within a few years it was generally believed that the whole Celestial universe was created about 6000 or 7000 years ago, just as it exists now, and the Nebular theory, or possible conversion of nebulæ, or star mist, into stars or planets, was considered as absolutely atheistic. Now! astronomers boldly state that it is highly probable that the nebulæ are representatives of that primordial matter out of which the existing stars and suns have been fashioned, and that in these remote celestial bodies we behold some of the stages through which suns and planets pass in

their development from luminous clouds. It is to the analysis of Light we owe such inductions. The analysis of light has taught the investigator the nature of a sun, the mysteries of a star, and the wonders of a nebula. The discovery of the moons of Jupiter by Galileo, and astronomical observations on their eclipses, led to the discovery of the velocity of light; the analysis of the same winged messenger has led to the discovery of a stranger history still, viz., the chemistry of the stars.

One of the most extraordinary discoveries of this age is the application of optics to chemistry by means of Spectrum Analysis.

It has been ascertained from experiment, that the phenomena of light and heat are connected with movements of intense rapidity, similar to those produced by vibration in sound; and Professor Miller in his lecture, delivered before the working men of Exeter, explained how the vibrations of certain sounds of the musical scale in one octave were twice as great as those in the octave below. Thus, in the treble C of the piano there are 512 vibrations, while in the C of the octave below there are only 256 vibrations, per second. So in Light—what the pitch of a note is in sound, such is colour in light.

It is well known that a certain number of substances, solid, fluid, or gaseous, which we call elementary, combine to form all varieties of terrestrial matter; and when any of these elementary substances, or compounds of such elements, are diffused in vapour, as flame, they impart to it peculiar characteristics, and by analysing the flame with the spectroscope the substance that colours and characterises it can be determined with the greatest accuracy. Each vapour emits a light peculiar to itself and which is collected into the spectrum into a line, or lines, peculiar to itself. Silver, for example, emits when heated to a vaporous condition a brilliant green light. Copper distilled into vapour emits a system of bright bands. Each metal or chemical element has its own set of bands, so that the examiner can at once recognise its presence in a state of vapour by its light and its lines in the spectrum. By such investigations lines belonging to several metals in a state of

incandescence have been determined in the spectra of the fire-works at the Crystal Palace, three miles from the place of observation, and the lines characteristic of barytes and strontia may be observed in the spectra of balls shot from a Roman candle, or illuminations in the Alhambra. By the same process also, within the last few years, several elementary bodies which exist in infinitesimally small quantities in certain mineral waters, such as cæsium, rubidium, thallium, and indium, have been added to the list of those elements which enter into the composition of our Earth.

Now it is found that a certain kind of Spectrum is characteristic of the light of a glowing solid, or liquid, or ignited cloud of *solid* particles; while a very different spectrum is exhibited when a *gaseous* body is examined—and to such perfection have these Spectrum investigations now arrived, that the examiner can look into a furnace through a prism and observe the changes occurring in its flame; or to the light of the Sun, where he finds undoubted evidence that metals such as are well known on this earth exist in a state of vapour in the sun's heated atmosphere, while to the very combustion of those metallic bodies we owe our light, and heat, received from that great luminary. Again the Spectra of some of the fixed stars have been mapped by Dr. Miller and Mr. Huggins. The spectra of sodium, magnesium, calcium, and bismuth were found in the light of Aldebaran, while Capella, Arcturus, Pollux, and Procion have all been examined, and sodium, hydrogen, magnesium, and iron have been ascertained to be among their chemical constituents.

I have already alluded to the fact that the "Continuous Spectrum" which is characteristic of the light of a glowing solid or liquid, or cloud consisting of glowing solid particles, is very different to the spectrum known as an "interrupted spectrum" which is comprised of the bright lines which are characteristic of incandescent gases such as flaming hydrogen, or the transparent vapours of vaporised metals. Besides this there is another spectrum presented, viz., when an intensely luminous solid mass is seen through a gas less intensely

heated. Such is the Spectrum of the Sun! and it indicates that the luminary of so many worlds is not a mere globe of molten metals, but consists of a central, heated nucleus, above which is an atmosphere with white hot solid particles in the form of vast clouds; and that outside there is a less heated *gaseous* stratum full of metallic vapours and masses of blazing hydrogen. While then some of the brightest of the Fixed Stars have been examined, and various metals are found to be floating dissolved in thin photospheres, as metallic vapours are detected in the photosphere of the sun, so there appear to be *stars* of differing and variable conditions. Mr. Huggins, when observing the spectrum of the variable star, T. Coronæ, which suddenly blazed out in 1866, was convinced that the sudden brightness was owing to the flames of *hydrogen gas* which diminished as the flames died out; and it is somewhat remarkable that hydrogen, which as a component of water is so abundant an element on our earth, should constitute the principal element of a numerous class of stars of which, according to Father Secchi, *α Lyra* is the type.—There be stars and stars! But if hydrogen has been detected in the blazing of a variable star; still more do those distant luminous clouds known as the Nebulæ give information, by means of their spectrum, of their chemical composition; and all which have as yet been examined appear to be in a state of gas or luminous vapour. "Three little lines," says the investigator, "dispose of the notion that true nebulæ may be clusters of stars." One line tells of the presence of nitrogen, the well known constituent of our own atmosphere, and corresponds with the line obtained in the air spectrum; another tells of the presence of hydrogen, and another of some new element or unknown gas. "True nebulæ are glowing masses of gas maintained permanently in a luminous state." Thus the "dumb bell" nebula, when examined by Mr. Huggins, afforded lines in the spectrum indicative of the presence of nitrogen; and the spectrum of the planetary nebula in Draco afforded testimony of the presence of both nitrogen and hydrogen. Again the examination of cometary matter by the

spectroscope leads to the conclusion that comets consist of highly attenuated matter, or meteoric dust.

The next step is to Meteorites, and meteoric stones, or aerolites (air stones). These are solid masses which have fallen from interstellar space upon the surface of this planet; they consist principally of iron and nickel; some specimens contain an admixture of augite, olivine, and hornblende. Shooting Stars are also understood to be meteoric masses which are continually shooting past us, and become visible at night, but which are too distant to allow of their being attracted by the earth's mass.

The result of the discoveries by means of Spectrum Analysis induces the astronomer and chemist to believe that all bodies in space are similarly but not identically constituted. Hydrogen had been recognised in the spectra of the fixed stars and in a variable star. So it was determined to see if meteoric stones, which bear evidence of having once been in a state of incandescence and of sudden cooling, would give any indication of the atmosphere where they were formed. Dr. Graham, therefore, examined the meteorite of Lenarto and found that it yielded 2·85 times its volume of gas, of which 86 per cent. was hydrogen. The meteoric stone of Lenarto had come from an atmosphere in which hydrogen was abundant, and thus, the meteorite which once travelled in remote space reached our earth, and shut up in it was hydrogen of the stars.

In this meteoric stone, therefore, we have an example of a condensed mass brought from interstellar space, bearing with it hydrogen occluded in metals, which metals are known to be in a vaporous state in the atmosphere of the Sun and fixed stars. The chemist believes also that such meteoric masses were once in a vaporous state, and that they became solidified as the temperature was lowered. Mr. Sorby, so well known for his microscopic researches, has no doubt whatever that the materials of which meteoric stones consist were once in a state of fusion. No less than 220 meteoric stones may now be seen in the British Museum, which have come to our earth from interstellar space, and all of which indicate that the materials

of which they are composed were once in a gaseous and subsequently in a molten state; while they are constituted entirely of elements and substances which also appertain to our own planet.

Again, it is interesting to know that the chemist and microscopist are assured that the deep seated minerals in the interior of this earth, which have been brought to the surface by volcanic action, bear a very close relationship to the structure of meteoric stones, and, pursuing this line of inquiry, they have been led to the conclusion that the materials of which the interior of this earth consist, were also once in a state of fusion.

Thus the astronomer finds reason for believing that suns and planets once existed as rudimentary matter; and chemists, mineralogists, and microscopists inform us that it is highly probable that materials in the interior of our globe which are now solid were once fluid, and before that were gaseous. To recapitulate, those who study with the telescope and spectroscope the chemical composition of stars, suns, and nebulæ, and those who study the chemical components of aerolites and planetoids, and the minerals, and metallic masses, in the interior of the earth's crust, believe alike, viz., that the various metals, and elementary substances, which compose that crust, possess a chemical nature similar to that which enters into the composition of the most distant bodies in space.

And if this be so, we are met with the profound thought that as far as human ken can reach, matter of a similar kind exists throughout a boundless universe; matter without compass, and without end. It is the fashion in these days to ignore all ideas of progress, and design, but we can hardly believe that it is possible for him who detects hydrogen in the spectrum of a nebula, or the blazing of a variable star, to avoid the speculation that when this earth was without form and void, the waters of our vast oceans may have been spread forth as the gaseous matter of a nebula, and that *Design* gathered the seas together, and filled the waters thereof with life.

As far as Man at present sees, all the phenomena of Nature

are connected, for the vaporous matter scattered through the dark profound of Space is as much impressed by the laws of gravitation and motion, as the planet which rolls around its sun. The laws of the elliptic motion of the planets, led Newton to the great principle of universal gravitation, which he would have sought for in vain in the less simple phenomena of the rotary motion of the earth.

May not there be in the counsels of the Most High, a Law which is impressed upon germs of suns and systems—germs organic and of life; a law which ever leads onwards by progression, and by which, in the evolution of ages, the nebula may become a world, no longer without form and void, but glowing with life and beauty, and by which the spirit of man, which even here is capable of sublime speculations, may in the future become more like that Spirit from whence emanate all laws, and all truths?

The gradual diminution of the primitive heat of the earth is believed by many to have been a cause which will account for the various changes which have succeeded each other on its surface, such as the expansions and contractions of its crust, and the sliding of a rigid crust over an internal fluid nucleus; and even to have been the principal cause of those alterations of Climate which the geologist knows have occurred in the history of the earth.

A further discussion of these speculative theories would, however, be beyond the province of the Geologist, and we will therefore pass on to the ground of ascertained facts, and seek to interpret the evidences derived from the rocky crust of the earth, since that remote time when it first became solid as it is now, and since which distant period we find but little proof that the intensity of internal heat radiated to the surface of this planet with greater force than it does at present. Geology has a field of its own, apart from all theoretic speculations as to the original state and constitution of our globe, and whatever difference of opinion there may be respecting the former fluidity and origin of the crystallised masses in the interior of the earth, there can be none con-

cerning the most ancient *sedimentary rocks*. They have continued to exist in their present condition for innumerable ages. It will be well, however, before quitting altogether the subject of the composition of the interior of the globe, to give a short description of Volcanoes, the effects of their extraordinary outbursts, and the nature of the mineral substances discharged from their craters; a few words also on the subject of Earthquakes will not be out of place, as both these phenomena, which have played so important a part in again and again remodelling the surface of the earth, have to a certain extent a common origin.

First, then, with regard to Volcanoes! We find that they have left undoubted evidences of their eruptions at a very early period of the world's history, in the shape of masses of a hard mineral substance, and beds of consolidated lava, intermingled to a great extent with the oldest stratified deposits. The general name of *igneous rocks* has been given to these ancient lavas, but in order to define more clearly the nature of the different materials of which they are composed, they have been divided into two classes—

VOLCANIC ROCKS,
AND
PLUTONIC ROCKS.

The term Plutonic is derived from Pluto, the ancient god of Hades, and is applied to such rocks as granites and syenites, which are believed to have been formed at considerable depths beneath the surface of the earth, and to have been cooled and crystallised under great pressure.

Volcanic rocks, on the contrary, although we believe them to have risen from great depths in the bosom of the planet, have cooled and crystallised nearer the surface more rapidly, and consequently without the same amount of pressure.

The formation of Plutonic rocks has of late years been much discussed by mineralogists and geologists, and although no mineralogist of repute believes that rocks such as syenite

and granite were formed by igneous agencies alone, yet Sir Charles Lyell, and those whose opinions are most trustworthy, think that it would be rash to infer that the manner in which the consolidation of granite takes place is very different from the cooling of lavas. Mr. Sorby of Sheffield, who has devoted much time to the careful study of the subject, arrives at the conclusion that the operation of *water* in the formation of granite is quite as powerful as that of *heat*, so that it may be roughly said that granite is *lava* steamed under great pressure.

The Minerals which principally compose these Igneous rocks are but few in number, and can be divided into six groups:—

Quartz,	Mica,	Augite,
Felspar,	Hornblende,	Olivine.•

A thorough knowledge of the chemical analysis of the varieties of these minerals would entail a long and careful study; suffice it to say here that the well known mineral substance called quartz or silica, is produced by the chemical combination of oxygen with silicon, for in the same manner that oxygen and hydrogen combine to form water, so oxygen and silicon form quartz, or silicic acid. The waters of the hot springs of Iceland and the Azores, which rise from volcanic depths, are found to be charged with silica in a state of solution, in the same way that the waters of other springs are saturated with carbonates or sulphates of lime.

Amongst the other volcanic minerals the most important are the silicates of alumina, lime, magnesia, potash, and soda; these also pass under the names of felspar, mica, hornblende, augite, and olivine. A chemical combination in certain proportions of silicic acid with the above first mentioned substances forms a variety of felspar rock, such as orthoclase, albite, or leucite. A similar process takes place with regard to micaceous and olivine rocks, silicic acid entering into combination in the same manner, produces in the former the varieties of talc, or lepidote, and in the latter the varieties of bronzite.

Lava is a term extensively applied to the immense quantities of molten mineral constantly discharged at the surface of the planet by active volcanoes, which serve as safety valves to the earth's crust. These are known to exist to the number of upwards of 400. In the Atlantic Ocean* alone, there are no less than five centres of volcanic action, while in Europe the principal centres are in Sicily, Naples, Stromboli, the Archipelago, and Iceland.

In order to form some idea of the masses erupted, and of the effect produced by these burning torrents, it will be sufficient to call to mind the fact that Mount Etna, although nearly 10,000 feet in height, and nearly ninety miles in circumference at the base, is ascertained to be entirely constituted of volcanic matter, which has slowly accumulated since the epoch known to geologists as that of the Newer Pliocene. It has poured forth from its crater floods of lava, some fifteen, some twenty, and some thirty miles in length, and in A.D. 1669, the dreaded stream inundated a tract of country fourteen miles in length and four in breadth, spreading destruction and desolation around its path, and burying beneath it 400 villas and other habitations. The cities of Herculaneum and Pompeii, likewise buried by the eruption of Vesuvius, the overwhelming of the town of Stabiæ in the time of Pliny, and the destruction of Torre del Greco in 1794, are farther instances of the effects of volcanic eruptions since historic times, but still more striking examples of these overflows can be cited. The volcano of Coseguina, situated in the Gulf of Fonseca in Central America, poured forth, in January 1835, such a mass of volcanic ashes and other matter as to cover the surrounding country for a distance of twenty-five miles to the depth of ten feet, destroying the woods and dwellings. Sir Charles Lyell records of this eruption that thousands of cattle perished, their bodies being often found reduced to a mass of scorched flesh ; many birds and wild animals were found suffocated in the ashes, and the neighbouring streams were strewed with dead fish. This

* See "Notes on Earthquakes," by the Author (Popular Science Review, Jan. 1864).

great eruption was accompanied by an earthquake which was felt for a distance of more than one thousand miles.

In Iceland, Skaptar Jokul poured forth lava for a period of six years. At its commencement in 1783, this eruption caused the death of no less than 9000 human beings out of a population which did not exceed 50,000 souls; an immense number of cattle were also destroyed. It has been calculated by Professor Bischoff that the lava brought up from subterranean regions by this single outburst would surpass the bulk of Mont Blanc in magnitude.

We have also evidence that volcanic eruptions into the sea, through fissures in the sea-bed, are by no means uncommon, though we have but little opportunity of judging of their effects. Islands have been raised by volcanic elevation within the historic period, such as the island in the Aleutian group, described by Langsdorff, which was elevated in 1793 to a height of 3000 feet. In the same year an island rose in the Azores; it was about a mile in circumference and about 300 feet above the level of the sea. It was composed of volcanic ashes and other light materials, and was soon washed away by the sea.

Santorino, White Island, New Burnt Island and several other islets in the Grecian Archipelago, are all due to submarine volcanic agency, and their elevation above the waters is recorded in authentic history. There are also numerous instances on record where the commanders of vessels have noted submarine eruptions as evidenced by the escape of gases and the destruction of marine animals.

In the region of the Andes, active and extinct volcanoes alternate for many hundreds of miles, and tremendous earthquakes frequently precede the different outbursts, while in Auvergne, Bohemia, Saxony, Iceland, we have examples, in European localities, of volcanoes which have become extinct since the period of the older Tertiary deposits. It is especially in Auvergne, Velay, and Vivarais that evidences of numerous extinct volcanoes are clearly seen. Every geologist should visit that picturesque and most instructive country, and a journey,

hammer in hand, through these provinces will convince the explorer of their having been the theatre of subterranean convulsions and volcanic eruptions throughout long ages, and at recent, as well as remote periods. In some localities the volcano has evidently ejected ashes and scoriæ after the lava had ceased to flow; in others, dome-shaped masses of domite, such as the Puy-de-Dôme, have been formed by a process likened by Mr. Scrope "to the effect which would be produced by heating a very thick soufflet pudding in a closely covered vessel, which it completely fills, until its intumescence forces it to exude through a crack or hole in the cover of the vessel, over which the matter, quickly congealing by exposure to the air, would cake into a bulky excrescence."

Traps, Basalts, and Greenstones are other forms of igneous rocks. When masses of volcanic matter are injected into fissures or clefts in stratified rocks, they are called *trap dykes*. Sometimes these masses are poured out over horizontal sea-beds, and as such are frequently found intercalated between stratified deposits. In such instances the strata, and volcanic overflows, have been often elevated together from the horizontal position they once occupied, and thus have the same dip and strike; while occasionally vertical masses are seen to have been injected into fissures which cross the line of dip. Sometimes beds of *volcanic ashes* are interstratified in like manner; they have been produced by volcanic explosions which have shot forth ashes and pumice into the air which, descending and falling into the sea, have gradually sunk to the bottom and formed sea-beds of volcanic materials often containing shells and other organisms.

The term "Trap" is derived from "trappa," a word in the Swedish language signifying a flight of steps. This name is given to rocks which, on account of their extreme hardness, constitute flights of steps or terraces, and it is a term now very generally applied to dykes, and igneous rock masses, which have been injected, or poured out under considerable pressure of water. The varieties of trappean rocks are chiefly basalt, greenstones, trachyte, dolerite, and porphyry; but, as the

names denote, they vary more in texture than in mineral composition; indeed trap dykes and rocks generally differ but little from modern lava, and it was years ago remarked by Dr. Macculloch, that "from lava to trap or basalt, and from them to syenite, porphyry, and granite, there is an uninterrupted succession."

In Basalt there is a great tendency to a columnar structure, and large masses are often seen divided into regular prisms. The experiments of Mr. Gregory Watt in the laboratory, on fragments of a trap rock called Rowley Rag, tend to prove that this peculiar structure is caused by its slow and gradual cooling. He melted 7 cwt. of this rock, and when the stony mass had at length cooled down he found that it was made up of polygonal prisms.

Among the most celebrated basaltic columns in this country are those of Staffa and Iona, the Giant's Causeway on the northern coast of Antrim, the so-called Samson's Ribs, on Arthur's Seat, near Edinburgh, and the Giant's Chair on the Clee Hills in Shropshire; while in the Ardèche are the beautiful columnar ranges of the valley of Montpezat, left exposed to view by the eroding influences of streams which have cut through the lava torrent to a depth of more than 100 feet.

In some localities basaltic or greenstone rocks weather into a globular structure. This singular structure is conspicuous in the large spheroidal masses quarried in a greenstone dyke on the flanks of the Malvern Hills, between Eastnor and the Hollybush Pass. Some of the smaller globules have the appearance of cannon-balls made of stone.

It is well known that Earthquake action is intimately connected with all volcanic phenomena.

It has been stated by Mr. Mallet, one of the highest authorities on this subject, that "an earthquake in a non-volcanic region may be viewed as an incompleted effort to establish a volcano." The question what is the cause of an earthquake may be answered by replying that elastic fluids which are compressed far below the earth's surface are probably the principal

cause of earth movements. But of the chemical nature of these gases, and their connection with the supposed fluid nucleus of our globe, we know nothing.

There are two modes of action in earthquake disturbances: one is the violent paroxysmal outburst, accompanied in general by the most awful destruction of human life; the other is that which slowly upheaves and depresses whole continents. The imagination can hardly picture anything more fearful than the results of the former violent movements. Mr. Mallet and M. Perrey, of Dijon, have catalogued systematically the different accounts of earthquake phenomena, and it has been calculated that several millions of human beings have been destroyed by earthquakes within the last 4000 years. Whether they occur along the line of the Andes, in the Indian Archipelago, in Sicily, or in Portugal, "Misericordia" is the cry, and dreadful indeed are the devastations which are witnessed by the survivors of such catastrophes.

Two hundred and fifty thousand persons were killed at the first earthquake of Antioch, A.D. 526, and 60,000 during the second catastrophe, seventy-six years afterwards. In A.D. 1797, 40,000 persons perished from earthquakes in Quito. Sir Charles Lyell records that 100,000 people were killed by the Sicilian earthquakes of 1693, when the city of Catania and forty-nine villages were levelled to the ground; and during the earthquake of Lisbon, in 1755, it was ascertained that 60,000 persons were destroyed in the course of six minutes. The other effect of the force of earthquake disturbance is seen in the gradual upheaval and depression of large tracts of country in various parts of the globe, and although this movement is in most cases extremely slow, and happily unattended by the disastrous consequences of the paroxysmal mode of action, it is nevertheless the cause of many of the great changes which are being accomplished on the surface of the earth. We know, however, but very little respecting these elevating and subsiding movements. Mr. Darwin believes that from the intimate and complicated manner in which elevatory and eruptive forces are connected with volcanic phenomena, we may confidently

come to the conclusion that the forces which at successive periods pour forth volcanic matter are identical with those which slowly and by little starts uplift continents. Again, Sir Charles Lyell, in his "Antiquity of Man," remarks, that from what we do know of the state of the interior of the earth, we must expect that the gradual expansion or contraction of different portions of the planet's crust may be the result of changes and fluctuations in temperature, with which the existence of hundreds of active and thousands of extinct volcanoes is probably connected. There are large portions of the earth's surface which have been elevated above the level of the ocean, in Africa, in the north of Europe, and South America, which bear no signs of paroxysmal upheaval, of volcanic overflows, or of any other than extremely equable movements. Sir Roderick Murchison informs us that there are in Russia large areas consisting of rocks of the age of the Lower Silurian epoch, which have been but partially hardened since they were accumulated, which have never been penetrated by volcanic matter, and have undergone no great change or disruption during the enormous periods which have elapsed since their deposition in the bed of the Silurian seas. With regard to present elevatory movements, it has been proved beyond a doubt that the land in Sweden and Norway is gradually being elevated out of the sea; and Mr. Lamont, in his "Seasons with the Sea-Horses," furnishes us with some remarkable evidence of the rapid elevation of the land around Spitzbergen, even the sealers observing that "the sea is going back."

We do not, however, need to journey to Norway or Spitzbergen for proofs of the elevation of land in recent geological periods, for since the period of existing shells Great Britain has been elevated to an extent incredible to those who have not studied the subject. The study of the drift and gravel deposits of this country will convince any geologist that by far the larger portion of Great Britain has re-emerged from the sea since the commencement of the glacial period, and that its emergence was gradual and slow. There are numerous instances in England, Scotland, and Ireland of nearly horizontal

stratified sandbanks, loose shingle, and gravel, occupying elevated positions, the appearance of which at once forbids the conclusion that they were hoisted up to their present position by any sudden paroxysmal disturbance, or by any other action than a series of gentle, and successive uprisings, and the gradual equable motion above alluded to.

Flint weapons have been found in many localities which prove that England was inhabited by an ancient people who lived in ages long remote, before the country had been elevated to its present position. The beds in which these flint implements occur are probably correlative in age to the celebrated drifts containing human tools in the valley of the Somme. Many caves containing human remains associated with those of extinct animals, have been greatly altered in position, and upheaved, since the deposition of the human weapons and the organic remains, while ancient land surfaces have, in other localities, subsided beneath the sea. Ancient canoes have been found near Glasgow in upheaved marine silts. Glasgow is an ancient habitation of the human race, and its University was founded on account of its "being ane notable place, with gude air, and plenty of provisions for human life." Nevertheless, in the words of Lyell, "at the time when these ancient vessels were navigating the waters where the city of Glasgow now stands, the whole of the low lands which bordered the present estuary of the Clyde formed the bed of a shallow sea."

Ceaseless change passes upon all we know of! Every planet in the universe moves in space; nebulæ become planets, planets change their condition, and physical phases, over and over again. The sites of our most populous cities may in the course of future ages become sea-beds, or Alpine summits. All tells of eternal change, and the indestructibility of matter.

CHAPTER II.

LAURENTIAN ROCKS.

Divisions of Primary Rocks—Canadian Laurentians—The Eozoon Canadense—Fundamental Gneiss of Scotland—Section of Queenaig near Loch Assynt—Plants at Inchnadamph—Glacier of Glen Baile—Laurentians of Cape Wrath—Loch Eriboll, Sections at—Laurentians of Ross-shire—Of Wales near Holyhead, Bardsey Island, Anglesea, and near Caernarvon—Laurentians of Malvern—Dr. Holl—Mr. Hugh Strickland—Antiquities of Malvern—Malvern Camps.

HAVING thus alluded to the general character and composition of Igneous rocks, I shall now follow the plan I have adopted in noting down these records. We shall take the rocks in ascending order, beginning with the most ancient, and give some account of their structure, and fossiliferous contents; but as this work is principally devoted to the description of Physical geology, I shall endeavour to describe the localities *where* the rocks may be studied in the field, adding at the same time a few notes respecting certain places which may prove not uninteresting to the botanist, and antiquarian.

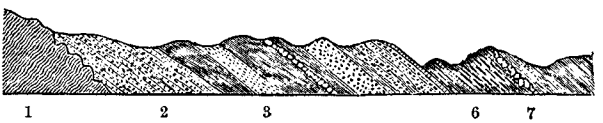
We recognise the following divisions of Geological time as regards the Palæozoic or Primary rocks.

7. Permian. On which the Trias rest unconformably.
6. Carboniferous.
5. Old Red Sandstone.
4. Upper Silurian.
3. Lower Silurian.
2. Cambrian.
1. Laurentian. Unconformable to the Cambrian.

It may give some idea of the manner in which this series of formations occur in nature, if we append a general diagram or

section, representing no particular locality; but merely the order in which the rocks appear as we proceed from the west to the east of our island.

GENERAL ORDER OF THE PRIMEVAL STRATIFIED ROCKS.



1, Laurentian. 2, Cambrians, Upper and Lower. 3 & 4, Upper and Lower Silurians. 5, Old Red. 6, Carboniferous Limestone and Coal Rocks. 7, Permians.

The Laurentian, or Basement, sedimentary deposits are divided into two series.

2. Upper Laurentian or Labrador Series.
1. Lower Laurentian.

These are the oldest known rocks upon the Planet's surface which afford evidence, by their stratification, of *aqueous deposition.*

The Laurentide Mountains of Canada are a chain of hills the general elevation of which does not exceed 1600 feet. They take their name from the River St. Lawrence, and underlie the entire series of stratified rocks known to the geologist. They consist principally of granitoid gneiss, hornblende, mica schists, and quartzite, with interbedded limestones of great thickness. They are traversed by dykes of volcanic rocks, such as greenstone and diorite. They attain a thickness of 4000 feet, and are believed to extend over an area of 200,000 square miles.

The Laurentian rocks were formerly supposed to have been deposited before the dawn of life upon the earth, and they were therefore ranked as appertaining to the *Azoic* (or lifeless epoch) of geologists, but after many years of hard work and strict searching, Sir William Logan and Dr. Dawson of Montreal succeeded in discovering in the Laurentian limestone what they believe to be the fossil remains of animals belonging

to the class Foraminifera, and closely allied, according to the opinion of the best authorities, such as Dr. Carpenter, and Mr. Rupert Jones, to Nummulina. The name of *Eozoon Canadense* has been given to these fossils, which are thus supposed to have been among the earliest living creatures on the earth. It is necessary, however, to observe that some microscopists, chemists, and geologists of repute, such as Messrs. King, and Rowney, and Professor Harkness, doubt altogether the existence of this fossil, and believe that it is merely a mineral aggregation of serpentinous and calcareous layers, and that the extraordinary variations it shows in size, shape, and structure, demand better proof of organic structure than is afforded at present.

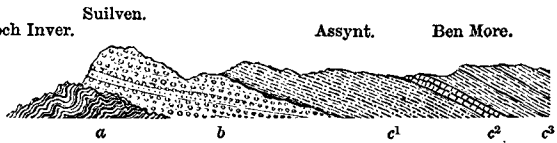
It is not only in America that these ancient strata are to be met with. Sir Roderick Murchison was the first to discover in Great Britain, the true geological horizon of certain rocks which are now generally acknowledged to be of the same age as the Laurentian gneiss of America. These beds were called by him "*Fundamental gneiss*," and they underlie Cambrian rocks which are unconformable to the gneiss. The best examples of Laurentian strata are to be found on the north-western shores of Scotland, in the capes and promontories of Ross and Sutherland, and the isles of the Hebrides. "This old gneiss," says Sir R. Murchison, "often occupies platforms of no great altitude, and for the most part constitutes low, rounded, bare hills, which resemble in outline the waves of a rolling sea." The basement beds of the overlying and *unconformable Cambrian sandstones* contain pebbles derived from the underlying fundamental gneiss, which indicates that the Laurentian strata had been *already altered into gneiss* before they were denuded, broken up, and rolled into the pebbles now imbedded in the Cambrian deposits.*

I have travelled on two different occasions with my friend Captain Price, on the north and north-west coast of Suther-

* See Professor Archibald Geikie's "Scenery of Scotland," and the contributions of Murchison and Geikie to "Quart. Journ. Geol. Soc. Lond.," for details on this subject.

landshire, and there seen the Laurentian gneiss in all its grandeur. Ben Stack, a mountain rising to the height of 2363 feet above the sea, is composed of these old deposits, which must gradually have accumulated, layer by layer, millions of ages ago. The best place to halt while exploring these old rocks, is at Inchnadamph,* near Loch Assynt.

SECTION BETWEEN LOCH INVER AND BEN MORE.



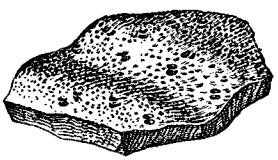
a, Laurentian Gneiss. *b*, Cambrians. c^1, Lower Quartz Rocks. c^2, Lower Limestone. c^3, Upper Quartz.

The section of Queenaig may be seen from the Loch Inver road, about three miles from Inchnadamph. At a point close to the road, opposite two small islands, is a roche moutonnée of the old gneiss, with a portion of Red Cambrian Conglomerate still adhering to it, and on the opposite side of the lake is a hill moutonnéed and rounded like a barrow, while a little farther on, at a small waterfall near a bridge, volcanic dykes may be seen traversing and altering the old gneiss. Ascending the mountain of Queenaig (2673 feet high), from the Loch Inver road, we pass over a series of steep rocky steps, and find the old gneiss covered unconformably by Red Cambrian Conglomerates, the pebbles consisting of rounded stones derived from the Laurentian gneiss beneath. Above the Cambrian deposits we find stratified masses of white quartzite of Lower Silurian age, full of annelid or worm tubes.

These beds cap the summit of the Auchmore peak of Queenaig. Nothing can be more marked than the step-like ascent, from the base to the summit of the hill, over these three geological

* The simplest and best way of reaching Inchnadamph is by mail car from Lairg.

formations, Laurentian, Cambrian, and Lower Silurian. The ascent of Queenaig on the eastern slope by the farm of Auchmore is easier, but the geology is more puzzling, for the Lower Silurian quartzite which caps the hill, dips down the slope on its eastern strike, and no section in the direction of Auchmore is to be met with without descending to the Loch Inver road. The spectator who ascends to the haunts of the ptarmigan, on Queenaig, beholds a weird and wonderful scene. He looks



BURROWS OF ANNELIDES.

upon low masses of rugged gneiss hills, which appear like a rolling sea, its waves frozen hard and fast as they rocked to and fro. These are interspersed with numerous lochs, and tarns, some glistening in the sunshine, others dark and black in shadow. To the westward, beyond the Minch, rise the Hebrides, and to the south-west the Matterhorn-like Suilven, and the lofty hills of Coulbeg, Canisp, and Coulmore. Everywhere around are ancient ice tracks, and the marks of glaciers which once protruded to the sea. The low, rounded, gnarled hills we look upon, towards Laxford, are studded with blocs perchés; and the "roches moutonnées" of the Alps, where the ice is but lately melted, are hardly plainer or more distinct.

When last we were on the summit of Queenaig, it was on an evening in October; the sun was setting brightly, a golden eagle floated in the air above our heads, while the snowfinch flickering past gave warning of approaching winter. Canisp and Suilven stood out like the Egyptian pyramids, to which Hugh Miller likened them, and we, who had examined their history, felt certain that their strata had been once continuous, stretching from peak to peak; that they had then been eroded, and cut out by ice, for high up, on all, are the striæ and

scratches of that powerful agent, which once had so great an influence in moulding the hills and vales of Scotland.

We are firmly convinced that the hollows, and gorges, must have been once filled by ice and snow, up to the very summits of the mountains, and that the land must have been occupied

Canisp. Suilven. Coulmore.

by them for ages. Before the commencement of this Ice-history, the strata on Suilven and Queenaig were continuous, and Loch Assynt had no existence.

In this district too there linger some relics of those Alpine plants which once no doubt clothed the land. Rubus chamæmorus* (the cloudberry), the food of the ptarmigan in Norway and Sweden, grows upon Glashven; Dryas octopetala† grows close to Inchnadamph, and Saxifraga aizoides shows its yellow blossoms by every rill. Still the Arctic flora on the west coast is not so abundant as on the hills on the north

* Rubus chamæmorus grows in the Highlands in Wales, in Scotland, and Cumberland; at the height of 300 feet in Siberia; and in the E. and W. of North America.

† Dryas octopetala grows in Wales, Yorkshire, and in Scotland. It is a sub-Arctic plant.

or east, owing probably to the warm influence of the Gulf Stream which sets in from the Atlantic. Nowhere did we find the dwarf birch (Betula nana), or dwarf willow, both of which occur on the mountains of East Sutherlandshire, on Clebrig, Ben Griam, and Ben Lloyal.

The explorer should examine Glen Baile, which lies between Ardoagh and Auchmore, the peaks of the mountain of Queenaig. From the top of this glen it is evident that one of the last of the glaciers in this district, a lingering relic of the ice that carved it out, descended to the Scourie road. The roches moutonnées of Cambrian Conglomerate are studded with blocs perchés of quartzite, and a good section is also presented of the unconformability of the overlying Silurian quartz rocks to the underlying Cambrian rocks. When visiting Glen Baile it is necessary to avoid a bad morass, and silted-up loch, at the end of this glacier glen towards Auchmore.

The range of the Laurentian or older gneiss in the Hebrides and North-western Highlands is very considerable. At Lewis, although much contorted, the real strike of the strata is across the island from S.E. to N.W., and not lengthways in the elongated shape of the island. The same history occurs in the country around Queenaig, for there the strike of the old Laurentian rocks is nearly at right angles to all the overlying deposits, a fact which applies also to the old gneiss of the Malvern Hills, which, as shown by Dr. Holl, does not run with the axis of the hills, but is transverse to the elongated axis of the range. The elongated axis itself owes its origin to the infiltration and subsequent upheaval of volcanic masses which traverse and overflow the Laurentian gneiss at right angles to its true strike.

In the north of Sutherlandshire, the old gneiss occupies the cliffs along the western shore of the Kyle of Durness; it has a grey hornblendic basis with veins of red syenite, and near the Ferry House on the Kyle affords good mineralogical specimens of asbestos and actinolite. They occur in the banks of a brook.

At Cape Wrath the botanist may gather abundance of Pri-

mula Scotica* in the months of June and July. The geologist may mark on the summit, and western slope, the rounded pebbles of Cambrian Conglomerate which, themselves fragments of the old gneiss, overlie the basement Laurentians.

From Cape Wrath the basement rocks may be traced as far as Loch Eriboll, where they are seen on the western shore in travelling from the ferry at Eriboll to Durness. Near the turn in the road also from the Kyle of Eriboll to Durness, opposite Whiten Head, some very striking blocs perchés should be observed on the rocks.

On the eastern side of Loch Eriboll the strata appeared to me thrown down along a fault where the loch now ranges, as the *higher* limestones and quartzites occur across the water. Here also is Eriboll House, the residence of Mr. Alexander Clarke, a hospitable gentleman, who is ever ready to assist the travelling geologist and naturalist, and, the friend of Sir Roderick Murchison, is well acquainted with the geological peculiarities of the district. He knows, too, the haunt of Rubus arcticus, and the rare, yellow Pinguicula (P. alpina).

The limestone and quartz rocks of the Durness country lie in a synclinal between the Laurentian rocks of Farrid Head and those that appear on the S.W. coast of the Loch of Eriboll, the limestone cave of Smoo lying also in this synclinal. From Durness a good section may be seen by following the Kyle up the river on the Scourie road†, and we here trace the rocks as they rise from under each other to the summit of the pass at the Gwalin Inn. The Durness limestone is seen resting on the quartz rock of the Parph, the quartz rock overlies the Cambrian Conglomerate, and near the pass the gneiss appears below the Cambrians. The Northern Char still lingers in a

* Primula Scotica grows also in Lapland, Norway and Sweden.

† A capital salmon river! Leave to fish may be obtained from Mr. Murray, at Durness Inn. It flows into the Kyle of Durness from a lake near Ben Spionno and Fashven. It is not long since I broke a trusty salmon rod with a fish hooked in the pool below the bridge on the Laxford road. The takes of salmon and sea trout in this river, when the water is in order, are seldom exceeded in Scotland.

glacial loch high up in the bare, ice-worn, glistening mountain of Foinaven.

But it is not only in Sutherlandshire that the geologist may see the relation of the Laurentian gneiss to the overlying deposits. In Ross-shire these rocks, overlaid by Cambrian Conglomerates and Sandstones, occur in Gareloch, on the eastern side of Loch Maree, and at Grabeg, on Loch Torridon, where they strike N.W., and pass under great mountain masses of Red Cambrians. Loch Maree is the wildest of the lakes of Scotland, while the geologist and lover of scenery can hardly find quarters better adapted for exploring the old gneiss and the ancient deposits that overlie it, than the Kinloch Ewe.

The junction beds of the Gneiss with the Cambrian rocks, may be seen on the Hasaach river, and at the base of the mountain Slengach. The gneiss ranges along the eastern side of the loch, and imbedded in it are thin layers of limestone which may, perhaps, yield to future investigators the remains of the Eozoon Canadense. This Laurentian limestone also occurs at Fuolith. As long ago as the year 1827, the two knights-errant of geology, Sedgwick and Murchison, described the Laurentian gneiss of Ross-shire, as perfectly unconformable to the overlying Cambrians, and as separated from them by thick masses of conglomerate. Their observations extended from the neighbourhood of Cape Wrath to the southern extremity of Applecross, and they discovered instructive junctions of the red sandstone with the old gneiss, between Loch Ewe and Gareloch. They were mistaken with respect to the *age* of the Cambrian strata, but they defined correctly the relations of the rocks to each other.

LAURENTIAN ROCKS IN WALES.

It has long been my opinion that the crystalline rocks of the Isle of Anglesea and Caernarvon Bay are *not* simply altered portions of the grits and slates which form the base of the Cambrian rocks in the counties of Merioneth and Caernarvon.

It does not seem possible that any chemical change could alter the Cambrian rocks proper into the gneiss and

schists of the South Stack lighthouse at Holyhead, or into the rocks of Bardsey, or those on the west coast of the Caernarvon peninsula. I expect that eventually it will be seen that all these rocks belong to a more remote age than that of the Cambrian formations, and that hereafter they will be classed as Laurentian, or at all events as Pre-Cambrian.

Belonging, however, to the class Amateur, we have no right to dogmatise, and shall merely refer to certain localities in Wales where these old rocks may be seen, such strata being generally grouped as metamorphosed Cambrians. These old crystalline rocks may be well seen at Bardsey Island, from which point they run along the western coast of the peninsula nearly as far as Nevin. The island derives its Welsh name of Ynys Enlli, or the "Isle of the Eddy," from the rapid tidal current which renders the passage over from the mainland difficult. The little town of Nevin sheltered the historian Giraldus Cambrensis in the days of Henry II. He speaks of Bardsey as being "wonderful wholesome" as regards its climate, "from some miracle obtained by the merits of the saints, many bodies of whom were said to be buried there, and among them David, Bishop of Bangor." To the north of Nevin an igneous, granitic, rock is quarried, called "Pistill granite."

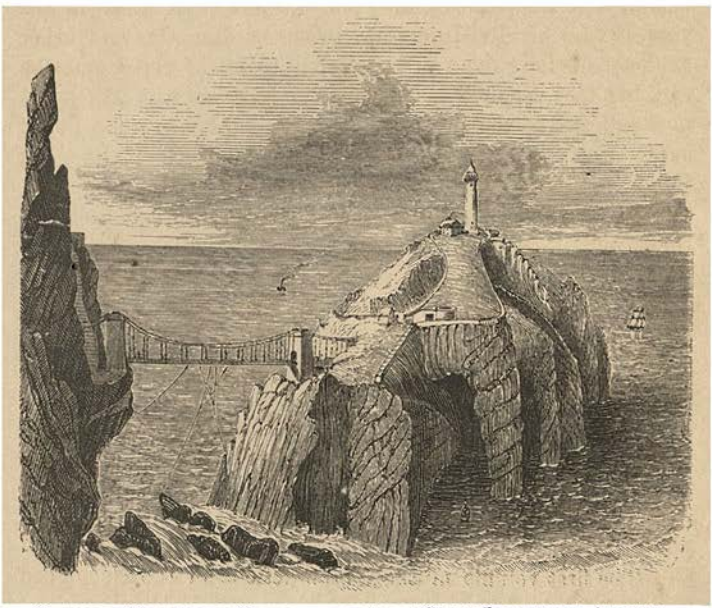
The whole of the Caernarvonshire peninsula is fine ground both for the antiquary and the geologist. At Parwyd, opposite Bardsey, are magnificent precipices of rock rising straight from the sea to a height of 600 feet.

The view from Yr Eifel, a mountain of trap which traverses Llandeilo strata and rises abruptly to the north of Nevin, is particularly fine. On its eastern flank are the remains of the early fortified town of Tre'r Caeri, considered pre-historic. On the south-eastern extremity of the Caernarvon peninsula, called Lleyn, is a patch of rocks which runs out to a point at Tryncilan, which has proved a geological puzzle, as nearly every one who has examined it holds a different opinion concerning its age. Sir H. de la Beche thought these beds were Upper Silurian; Prof. Ramsay regarded them as Middle Silurian; Mr. Salter believed them to be Lower Llandeilo; and

lastly, the Geological Survey have determined to call them Cambrian, although they do not resemble the rocks on the opposite coast, and have no Lingula Flags overlying them. The crystalline rocks of Anglesea with their quartzose and felspathic rocks, extending in broad masses over the greater part of the island, were described by the late Professor Henslow in the year 1822. Sir R. Murchison, Professor Ramsay, and other geologists believe them to be altered rocks of the Cambrian age, but they resemble so closely the rocks of the Malverns, now assigned to the Laurentian age, that there is some doubt as to whether they are not of older date than the true Cambrian strata on the other side of the Menai Straits. Several greenstone dykes strike across the island, but some of these, like those at Llanberis, are probably of post-Silurian date. The metamorphism of the so-called Cambrian rocks of Anglesea appears to be connected with the intrusion of granite and serpentine near the southern extremity of Holyhead Island, for there is a large mass of serpentine, also volcanic grits and dykes, which appear to be interbedded with the altered strata and contemporaneous with them. The granite of Anglesea extends from the south-west coast near Llanfaelog towards the mountain of Bodafon, and near T-afarn-y-botal, south-west of Llanerchymedd, granite veins are interstratified with veins of gneiss, in the same manner that the syenite veins are interstratified with the old gneiss of the Malverns; both the granite and gneiss appear to be the result of deep seated metamorphism. Sir Roderick Murchison gives a beautiful sketch in his "Siluria".* of the altered and contorted strata at the South Stack lighthouse near Holyhead. The beds have been altered in one place into quartz rock; in another into chloritic and mica schists; and they are twisted and contorted in a remarkable manner. The promontory is famous for its scenery and the innumerable sea-fowl which frequent the rocks. It is worthy also of remark that a rare plant, Helianthemum Breweri, grows on Holyhead mountain and near Amlwch, Anglesea.

* 3rd edition, p. 35.

I believe that the Twt Hill behind Caernarvon is a metamorphic rock of pre-Cambrian date, as it is a stratified rock traversed in all directions by volcanic masses which alter the overlying strata; and apparently the metamorphism both of the Cambrian and Silurian rocks took place during the Lower



CONTORTED CRYSTALLINE SCHISTS AT THE SOUTH STACK LIGHTHOUSE, ANGLESEA.

Silurian period, for in the neighbourhood of the Menai Straits, a fault occurs by which the unaltered carboniferous deposits are brought in against the old granitic gneiss, which we imagine to be pre-Cambrian, and in that district the Lower Silurian deposits are metamorphosed and changed.

In South Wales a syenitic axis occurs near St. David's. The stratified gneiss evidently protrudes through the Cambrian rocks proper, and appears to be of older date. We called the attention of Mr. Salter to this fact years ago, and the same

opinion is held by Mr. Hicks. This rock is probably of the same age as the rocks of Bardsey Island.

LAURENTIAN ROCKS OF MALVERN.

MALVERN HILLS, FROM THE WEST, NEAR EASTNOR.

North Hill. Worcestershire Beacon. Herefordshire Beacon

The classification of the gneiss of the Malvern Hills has been a subject of much discussion amongst geologists, but at length, after impartial inquiry and strict examination, its claim to be ranked as belonging to a series of such antiquity as the Laurentian rocks may be considered as fairly established. Many years elapsed, however, before this conclusion was arrived at. The first volume of the "Transactions of the Geological Society," established in 1807, contains an admirable account of the Mineralogy of the Malvern Hills, by Leonard Horner, Esq., then Secretary to the Society. He remarks upon the slaty structure and fissile appearance in the rocks of the range, and observes that they "were probably formed by successive depositions," but he treats the masses of the hills generally, as composed of syenite, and consisting of the different minerals—felspar, hornblende, quartz, mica, and epidote.

Again, the *Gneiss* which enters so largely into the structure of the Malvern range, was observed by Sir R. Murchison, Prof. Phillips, and others, to be regularly stratified in layers, but it remained for Dr. Holl of Worcester, who has had much experi-

ence among the Laurentian deposits of Canada, and among rocks of the same age in the Appalachian chain, to point out that it is highly probable that these old gneissic rocks may date from Laurentian times, and that it is almost certain that they are older than the Cambrian rocks of the Longmynds. Many local geologists were long adverse to Dr. Holl's views on the subject; but farther inquiry and personal investigation convinced them that the rocks which composed the Malvern range, were already metamorphosed, uptilted, denuded, and formed into a ridge before the deposition of the Lingula flag series; while the researches of the Rev. Mr. Timins, a good chemist and mineralogist, go far to prove that no amount of metamorphism could possibly alter the Cambrian rocks as we know them in Wales, or the Longmynds, into crystalline rocks, such as those of the Malverns, or Scotland, which we term Laurentian.

It is very probable that some of the black-looking greenstones of the Malvern Hills, which appear to be interbedded with the old gneissic stratified rocks of the range, may be Volcanic rocks of Laurentian age. They may be seen in places regularly bedded with the old gneiss, whatever may be its age, and cannot be separated from it, as regards contemporaneity, any more than we can separate the Trap, and Volcanic Ash, of Snowdon from the bedded strata of the Caradoc period.

When the geologist crosses the North Hill and the Worcestershire Beacon, he must bear in mind that they consist of various kinds of *gneiss*, traversed by trap dykes, and interbedded with layers of greenstone. With these are stratified crystalline rocks, such as hornblende schist, mica schist, felstone syenite, and granite.*

The Herefordshire Beacon presents a somewhat peculiar feature to the geologist. On the east of the turnpike road is a fine excavation in the old gneiss, where the bedding may be well examined, as also the infiltration of a trap dyke, whereas on the north, at the back of Mr. Johnson's house, bedded rocks

* Specimens of these may be seen at the Malvern Museum, at the College.

of the age of the Upper Llandovery deposits may be seen, caught up among the uplifted Laurentian gneiss.

The hammer of Dr. Holl has also been brought to bear along the *eastern slopes* of the Herefordshire Beacon, and it is his impression, as well as that of one who has hammered in his wake, that there are deposits on that slope much less highly metamorphosed than are the crystalline rocks of the Malvern axis generally, and that these deposits require farther investigation in order to determine their age and relation to the Laurentian gneiss. It is difficult to carry on these researches on account of the turf which covers the hill and conceals whatever rocks may occur.

On the western flank of the Midsummer Hill, and on the adjoining Ragged Stone Hill, we obtain proofs that the rocks which compose the axis of the range were all of them cooled and crystallised before the period of the deposition of the Hollybush Sandstone, which is now ascertained, from its imbedded fossils, to be a representative of the Upper Lingula Flags of Wales. This Hollybush Sandstone rests unconformably *upon* the upturned and uptilted edges of the old gneiss, as is well seen in the great quarry of the White Leaved Oak; and any one can trace out this evidence for himself by observing the saddle of Hollybush Sandstone which overlaps each side of the hill, and the manner in which it dips east and west of the ridge between the quarry and the road. Moreover, by going a little distance to the east of the White Leaved Oak quarry, and by a small cottage in a romantic glen, we observe that the infiltration of certain greenstones and traps was *posterior* to the general uplifting of the old gneiss, from the way in which its bedding has been broken through by the outburst of these volcanic masses.

The fact that a long period intervened between the upheaval and dislocation of the Malvern axis, and the deposition of the Hollybush Sandstone (or Upper Lingula Flags), is plain enough to any observing geologist. The question is, what has become here of the Lower Cambrian rocks? Our reply is, that in all other regions where these rocks have been

observed, there *is a general conformity* between the Lower Cambrian deposits, and the overlying Lingula Flags, therefore the *utter* unconformity between the *old gneiss* at Malvern, and the Upper Cambrians, or Lingula Flags, of the Hollybush Sandstone group, implies that a long interval of time must have elapsed between the deposition of these distinct formations. We may infer, consequently, that if any Lower Cambrian sediments were deposited upon the Laurentian gneiss, they must have been denuded and washed away before the deposition of the Lingula Flags or Hollybush beds.

This is the case in Scotland. In Assynt, and many other localities westward, we have splendid masses of Cambrian rocks overlying the old gneiss; but to the eastward, they thin out or are denuded, and quartz rocks, believed to be of the age of the Llandeilo series, rest upon the Laurentian gneiss. In the Malvern area there is evidence that great depression was going on between the Lower Cambrian period and that of the Lingula Flags which overlap the southern flanks of the hills; and it is impossible to calculate the amount of denudation which took place during such depression. It is recorded in "Old Stones," that the best plan for explorers of the Laurentian rocks of the valley of the White Leaved Oak, is "to drive to the 'Duke of York,' a village hostelrie at the foot of the hills on the Ledbury and Tewkesbury highway, and a short walk from thence across the fields will lead them to the valley. A little stream wanders from among the rocks of this narrow gorge, and on the banks the earliest violet and primrose may be found."

On the left of the valley is the Chase-end Hill (or end of the Malvern Chase, vulgarly pronounced Keysend), and on the right is the now famed Ragged Stone Hill. It was on the summit of the "Ragged Stone" that, in 1853, Mr. Hugh Strickland, then Reader in Geology at Oxford, gave his last lecture to an assemblage of naturalists, who gathered around its peak to listen to one who was ever ready with a kind word, and courteous hand. Now, "when the setting sun lights up the peaks of the 'Ragged Stone,' it shines full upon the

obituary window erected to his memory in the old church of Deerhurst, in the Severn vale, and those last rays play upon the words, 'To the memory of Hugh Edwin Strickland, the tribute of many friends.'"

The view from the summit of the Malverns is most extensive, presenting also a varied series of geological formations. Looking westward, the different groups of the Silurian rocks are seen succeeding one another in due order, and passing upwards into the Old Red Sandstone of Herefordshire, while still farther in the distance may be discerned hills capped with mountain limestone, outliers of the Carboniferous system. On the south-west, the Silurian rocks again appear on May Hill, the flat country stretching between it and the Malverns being occupied by Triassic strata. Lastly, to the east are seen low detached hills capped with Lias, while farther away to the south-east rise the Oolitic hills of the Cotswold range.

When the antiquarian roams with the geologist, he should remember with Bishop Tanner, that "Great Malvern was a place of great antiquity, for here, in the wild forest, was an hermitage, or some kind of religious house, before the Conquest, endowed by the gift of Edward the Confessor."

The ancient name of Malvern was Moel-y-yarn = High Seat of Judgment. It is recorded that as early as A.D. 925, Athelstan, the grandson of King Alfred, attacked Margadad, the King of South Wales, who dwelt "in Malvern, near the Severn, 'with very mickle folke,' and drove him with his weapons over the Wye, and took from them the land that lieth there betwixt." *

In later years, Werstanus, Prior of the Monastery of Deerhurst, near Tewkesbury, is said to have founded a chapel at St. Ann's Well, for Leland, in his "Itinerary," records that "Bede maketh mention that yn his tyme there was a notable abbey at Deerhurst, it was destroyed by the Danes, Werstanus fledde thence, as it is sayde, to Malverne." Werstanus is supposed to have been murdered by the Welsh, and the scene

* Laymon's "Brut."

of his violent death is represented in one of the old windows of the Priory Church. The date of this glass is about Edward VI.'s time. Leland dates the erection of Malvern Priory about 1084. The massive Norman pillars of the church were probably built by Prior Aldwin, the friend and follower of Wulstan the last of the Saxon bishops, who lived from the days of Canute, with whom he had conversed, to assist in the coronation of the Norman King, William Rufus. The Priory was an important establishment up to the time of its suppression by Henry VIII., for it was visited by Henry VII. in company with his queen and Prince Arthur. It was during the reign of Henry VII. that the greater part of the present church was erected. At the dissolution of monasteries and religious houses by Henry VIII., Latimer, then Bishop of Worcester, entreated the king to spare Malvern Priory, offering him the sum of 400 marks, and 200 marks for his secretary. He also pleaded the noble character of the Prior, "Toching prechynge, studye, with prayinge (to the which he ys much givyne), and hospitalyte." It was, however, given by the king to a Mr. William Pinnock, whose heirs sold the church for 200*l.* to the parishioners.

The summits of the Malvern Hills were the sites of many ancient encampments. On the top of the Herefordshire Beacon are the remains of a British camp with a treble ditch, covering upwards of forty acres. It is supposed that it was afterwards occupied by the Romans, who invaded this district under Ostorius Scapula, A.D. 50. Some years ago many Roman coins were found here. Their date ranges from Diocletian to Maximinus Daza. My friend Mrs. Stone, of Chamber's Court, in this county, found some silver coins here, but as they have been lost I am unable to give their dates. There is not the least probability that, as has been supposed, this was the scene of the last struggle between Caractacus and Ostorius, for Tacitus clearly refers the geography of the spot where this fight occurred to the site of the Breiddan Hills. The Malverns do not at all correspond to his description.

Another encampment, said to be Danish, is traceable on the

hill known as Midsummer Hill, north of the Tewkesbury and Ledbury high road.

On the summit of the Worcestershire Beacon, among the syenitic débris, an old British drinking cup was dug up. It is now in the possession of Mr. Edwin Lees.

A boss of syenitic rocks is protruded along the line of the Abberley Hills. It is seen only in one locality near Martley, and also between Berrow Hill and King's Common. It is similar in character to the rocks of the Malverns, and if they be Laurentian this should claim the like honour of antiquity.

Charnwood Forest is a difficult district to work out, with its bosses of syenite, its porphyritic ridges, and its slaty rocks. There is gneiss there, like the Laurentian gneiss of Scotland, and the strike of the rocks is S.E. by N.W., and altogether different from the strike of the Longmynd Cambrians. I was struck with this feature some years ago, and Dr. Holl believes in their pre-Cambrian age, and that they are an extension of the Malvern axis of Laurentian gneiss faulted to the surface by an earthquake upthrow. The principal upthrow is towards the S.W., and bosses of syenite and greenstone run from New Cliff towards Bradgate. Mount Sorrel is a syenitic mass, and so is Cliff Hill, and Bardon. In some localities there is a transition from syenitic gneiss to a porphyritic rock, and greenstone; and sheets of greenstone have been poured over the coal measures at Snibston and Whitwick. The *Drift* of this district is interesting as showing that Charnwood Forest was submerged, during the period of the Northern Drift, and was under water when the quartz pebbles of those seas were deposited on the heights of the Cotswolds. My friend Mr. Lucy directed my attention to the boulders on the N.W. of Bardon Hills, and shewed me flints, lias, gryphites, and fragments of coral rag from Mount Sorrel, Beacon Hill, and Bawdon.

CHAPTER III.

CAMBRIAN ROCKS.

Lower Cambrians.—Sedgwick on—Cambrians of Scotland—Hugh Miller on Scenery of Assynt—Cambrians of Ireland—Cambrians of the Longmynds—of St. David's, S. Wales—Giraldus Cambrensis, his Birthplace, &c.—Boulder Rocks around St. David's—St. David and his Preaching—David the Second and his Pipes—Cathedral of St. David—Lower Cambrians of N. Wales—Dolbadarn Castle—Ramsay on Glacial Striæ—Glacier of Cwm Grainog—Llyn Idwal—Caernarvon—Moel Tryfaen and its Drifts and Shells—The Maenbras—Glacier of Carnedd Llewellyn—Antiquities of Bangor and Rocks of—Fossils of Lower Cambrians—*Upper Cambrians* of Barmouth and Harlech, Gold Rocks of—Porus's Grave—Sarn Helen—Lingula Flags of Snowdon—Penryhn Slate Quarries—Lingula Flags of Shropshire, Herefordshire, and Malvern Hills—Miss Margaret Lowe and Black Shale Trilobites—Tremadoc Rocks—Ramsay and Salter on—near Portmadoc.

CAMBRIAN VOLCANIC ROCKS.

THERE are numerous examples in North Wales where rocks of the Cambrian epoch are traversed and altered by volcanic rocks, but as many of the greenstone dykes penetrate and metamorphose the overlying Silurian rocks, they can hardly be said to belong to the Cambrian period.

In Merionethshire, the Cambrian rocks may be seen altered by porphyry and traversed by greenstone dykes in the district of Crawcwell, a few miles south-west of Ffestiniog, but on Llawllech, the long mountain range north of Barmouth, true beds of volcanic matter, felstone beds, and beds of ash, grey in colour and of every kind of hardness, are found interstratified with the hard Cambrian slate. Mr. Salter, while examining the gold district, found that some of the masses marked as greenstone in our maps are really beds of fine

volcanic silt and felspar rocks, which pass by such insensible gradations into the slates which lie both above and beneath them, that no doubt can be entertained of their having been poured out as lava floods, and strewed as beds of ashes upon the floor of the old Cambrian sea.

The same history occurs in the wide moory valley which opens towards Trawsfynydd, near the entrance to the passes of the Diphwys Hills. Here, among the beds of purple and greenish slates, are long ranges of a schistose, felspathic, rock, occasionally solid and crystalline, but in other beds flakey and mixed with the slate, and often assuming the form of that peculiar kind of rock which the Germans call "Schaalstein." This was distinguished long ago by the veteran Sedgwick as recomposed felspar trap.

LOWER CAMBRIAN ROCKS.

		Organic Remains.
2. Upper Beds	Harlech grits. Menevian Beds	Trilobites, Theca, &c.
	Longmynd Rocks	Palœopyge Ramsayi, Worm tubes, &c.
1. Lower Beds.	Llanberis Slates	Oldhamia, Worm burrows.
	Conglomerates of Scotland	

As early as the year 1831, or 1832, the name of "Cambrian" was given by Professor Sedgwick to these rocks, as well as to many which overlie them, on account of their being found largely developed in Wales. The few fossils which had then been discovered in these formations were supposed to be the relics of the earliest created animals on the surface of the earth, but owing to the discovery of Foraminifera in the older Laurentian rocks, this idea must be abandoned. It has been already explained that the discovery in the West of Scotland of pebble beds at the base of the Cambrian rocks (the pebbles consisting of old Laurentian gneiss), together with the unconformability of the Cambrian deposits to the underlying Laurentians, indicates the lapse of a long intervening period.

So again we have evidences of a long continuance of the Cambrian period, in the vast thickness of sedimentary rocks accumulated in Shropshire to a depth of several thousand feet, and which are known as the rocks of the Longmynd.

The Laurentian deposits of Great Britain are generally so altered, contorted, and upheaved from their original horizontal position, that it is sometimes difficult to realise the fact that the particles of which they are composed must have had the same history attached to them, and their rock structure, as that which applies to the newest sedimentary deposits we behold in our geological researches. But this is not the case with the overlying, and unconformable, Cambrian rocks; their conglomerates, bedded sandstones, grits, and ancient mud layers changed into crystalline slates, all look as if they had been worn down by the action of water, had been transported by water, and deposited in water. There can be no mistake about these stratified Cambrian rocks of Sutherlandshire, of the Longmynds, and of Wales, for they bear in their structure indisputable evidences of having been deposited by the action of waters which denuded pre-existing land, and distributed the débris, and sediments, over the beds of seas, or lakes, in the very same manner as sediments are being deposited at the present moment by aqueous action.

We know somewhat of the effects of those aqueous and atmospheric forces which act as powerful agents in changing the contour of the globe; for the solid earth we live upon is everywhere wasted day by day, and night by night, by the action of the atmosphere, winds, rains, snow and frost. The weathered letters of an old tombstone are but the heralds of the decay of the tombstone itself; the air, the rains, the frosts, have weathered the legend that recorded the praises, or bemoaned the departure of some worthy of days gone by, but that weathering will go on until the stone itself shall have crumbled into dust. Water percolates into fissures upon the rocks of the mountain, and frost hurls enormous fragments down the glen, or on the glacier, while the mass that is thus detached from the mountain is in time distributed as mud, or

gravel, or sand, over the beds of seas, estuaries, or lakes, and the pebble we gather upon the shore to-day, may be the relic of a great rock that lingered upon a glacier for years, or centuries.

Every continent is gradually being wasted by the aqueous, and atmospheric forces. The sea does its slow but sure work, and every coast is now being wasted by the wash of waves along the shore; while the action of frost and snow, rain and rivers, is still more marked. It has been calculated by Professor Geikie that denudation in the Highlands of Scotland proceeds at the rate of one foot in 6000 years, or 1000 feet in six million years, the carrying power of every river system depending upon the fall of the ground, the annual amount of the rainfall, and other circumstances. Enormous are the masses of sedimentary matter deposited in estuaries by such rivers as the Amazon, the Mississippi, and the Ganges, and which in future ages must be converted into land. Thousands of human dwellings now stand on sites where ages ago there rolled the waters of a sea, or lake. The vast plains of America, the prairies and the pampas of the wild Indian of the Far West, are derived from the water-worn débris which has been washed down from the mountain lands of the Andes and the Rocky Mountains; and we may say the same of thousands of square miles among the plains of the Old World. But if this be true of modern sediments, is it not equally true of old Laurentian and Cambrian rock sedimentary matter, that, as says the Preacher, "it hath been already of old time which was before us." The physical construction of the Laurentian and Cambrian strata had a history similar to that which modern sea-beds or lake-silts have now; but what of the land from whence they were derived? what of the continents, and islands, the sea waves washed, or the rivers which rolled through them? What of the animals and plants of those lands, if such there were? Of these we know nothing, and perhaps never may!

CAMBRIAN ROCKS OF SCOTLAND.

The Red Sandstone, which rests unconformably on a base of gneiss at Gareloch, in Ross-shire, and in Assynt, in Sutherland-

shire, where it forms the insulated hills of Suilven, Coulbeg, and Coulmore, was considered years ago by Dr. Macculloch to be but the mere fragments of a once continuous sandstone bed, varying from one to two thousand feet in thickness, and much the greater part of which had been washed away by the waves and currents of untold ages. Hugh Miller, too, journeyed to Loch Inver, and, following in the wake of others, assigned to these red mountain rocks the geological position of the Old Red Sandstone. It remained for Sir R. Murchison and Mr. Carrick Moore to show that they were overlaid by Lower Silurian quartz rocks, and limestone, and eventually to identify them with the old Cambrian deposits of Wales and the Longmynds, and having myself hammered in these localities, I fully concur in the correlation assigned.

The red Cambrian sandstones, where not carved out or denuded, rise into some of the noblest mountains in Scotland. I have already alluded to the peculiar scenery which distinguishes the aspect of the country around Queenaig, near Inchnadamph, the barrenness of the grey cold hills of Laurentian gneiss, with the multitude of tarns, and lochans, that lie in their dreary hollows, while at sunset few views are more striking than the hill of Ardmore of Queenaig, rising with its red rocks against the sky. A closer examination convinces us that these accumulated strata of conglomerates, sandstones, and marls must have been gradually deposited, inch by inch, on the floor of the still older stratified but uptilted gneiss, as stratified sandstones, and silts, are deposited on sea-bottoms at the present day. These old Cambrian strata are, to all intents and purposes, ordinary sedimentary deposits.

It is impossible to explore the Cambrian mountains of the North-west Highlands without being convinced that the character of Highland scenery has *not* been mainly determined by subterranean movements, but that, as Dr. Macculloch maintained, *erosion* has removed hundreds of feet of solid rock from above the Laurentian gneiss, and, in other localities, from above the red Cambrians themselves. Waste is the agent which has carved out the present system of glen and mountain, valley and

lake. Waste by seas, and currents, long since passed away, waste by ice and frost, and rains and streams, in later times. There is little left of the effects of earthquake action, save for him who looks closely to the contortions and dislocation of the old gneiss, or to the underground movements which have caused faults often difficult to detect; or the outburst of a volcanic dyke, splitting and altering the rocks which it traverses.

The Cambrian rocks on the western shores of Loch Maree, in Ross-shire, rise into lofty hills, capped here and there by the lower quartz rocks of the Lower Silurians, the contrast of the snowy-white quartz giving rise to the local name of "Ben too leash," or the "Greyheads." There are fine sections to be seen in the mountains of Applecross, and on the southern side of Loch Torridon.

The geologist should make himself well acquainted with the rocks which *overlie* the red Cambrian formation, as it is on them depend so much not only the picturesque scenery of the country, but also the numerous wild plants which abound in these northern districts.

The Cambrians of Queenaig are covered by a *Lower Quartz* rock (the same beds which occur at Loch Maree), with cylindrical worm tubes, which long ago were regarded by Macculloch as organic, and numbers of which may be seen imbedded in the quartzite on ascending the hill from the east, beyond the farm of Auchmore.

This lower quartz rock dips to the east from the summit of Queenaig, but the explorer will easily observe, when journeying north-westward on the Scourie road, how it dips under and is covered by a bed of *limestone*, which itself is surmounted by the *upper* quartz rock of Glashven. The rich green of the grass, and the numerous wild flowers, among which are Dryas octopetala, and Rubus saxatilis, with many ferns, such as Asplenium viride, the Holly fern, and Osmunda regalis, mark at once the limestone dells.

This *Lower Limestone* presents a noble range of rock escarpment, which rises immediately above the Lairg high road, near

the inn at Inchnadamph. In this neighbourhood there are also limestone caves, and by following the course of a rushing stream, a junction may be seen of the limestone with the *Upper Quartz* rock, which rises in great thickness to the summit of Ben More, where, near the peak, it is overflowed by a greenstone dyke. The upper quartz rock, with the underlying limestone, and lower quartz rock of Queenaig, are believed to be about the age of the Llandeilo formations of Wales, and form the greater proportion of the highest hills in the country, such as Glashven, Ben More, and Ben Hie. In this upper quartz rock occur, however, *two* intercalated bands of limestone, and I am of opinion that the marble quarries near Ledbeg, on the road to Lairg, constitute a higher series of strata than the lower limestone near Inchnadamph. A similar history attaches to the strata on the shores of Loch Eriboll. Here the beds thin out on their eastern strike, but the succession is well displayed, and I was thoroughly convinced of the occurrence of two bands of limestone on the hills of *upper quartz* to the east of Eriboll House. Here also the upper quartz rock forms, on the west, the high mountain ranges of the Reay Forest, and the noble hill of Fronven, while on the hill of Eriboll, and between Loch Eriboll and Loch Hope, we find that it is covered by an *upper gneiss*, which differs entirely in its mineralogical character from the old Laurentian gneiss. The gneiss of the Moin, of Ben Hope, and of the east coast generally, is a far more micaceous deposit than the old gneiss of Cape Wrath, and Assynt; and as regards their stratigraphical relations, they must be separated by some thousands of feet of intercalated deposits. One of the rarest British plants, *Alsine rubella*, grows on Ben Hope. It is eminently an Arctic plant, abundant in Lapland, but in all Great Britain it is only known on this wild hill in Sutherlandshire, and on Ben Lawers on the north shore of Loch Tay.

If we were to sink a shaft on the top of Ben Hope, the great hill east of Eriboll, and west of Tongue, we should expect to find the *upper gneiss* (which is probably the representative of some Lower Silurian strata, perhaps Caradoc) underlaid

by the upper quartz rock of the summit of Ben More, and many other mountains to the west; in these quartzites would occur the intercalated limestone bands of the Smoo caves near Durness, those of Inchnadamph, and the upper beds of Ledbeg; while below these again would be the lower quartz which caps Queenaig, Suilven, Canisp, and the fine hills of Assynt. Sinking down through this lower quartzite, we should find the red Cambrian conglomerates and sandstones, which form so striking a feature in many of the mountains of Ross-shire; and at length below these again, the old Laurentian gneiss, grey, twisted, and contorted.*

It is not long since we stood upon an old roche moutonnée close by that wild loch of Assynt, and read these words of one, who some years before directed our attention to a scene which must ever be a most striking one to the physical geologist who has learned to read its history. In the following words Hugh Miller describes the scenery! "In looking up the dark narrow lake which takes its name from the district, we see the broad bases and naked storm riven summits of Ben More, and the neighbouring mountain Glashven, forming the background of the landscape. The ancient castle of Ardvorak, and the old mansion-house of Eddrachalda, both broken and roofless ruins, situated within a few hundred yards of each other, the one shattered by lightning, the other scathed by fire, comprise from one interesting point of view the only human dwellings visible in the prospect; solitude broods around, the distant hills, bald, verdureless, and hoary, seem the hills of a worn-out desolate planet, and harmonise well with the deserted ruins and the dark lonely lake beneath; and altogether so impressive and unique is the scene, that, when I first looked upon it through the lurid haze of a stormy evening, it seemed suggestive of universal death and extinction, the lifeless old age of creation."

As we read this, the mail car rattled past from Lairg to

* Captain Price, M.P., found stratified sand and gravel on the summit of Ben Hope.

Loch Inver, with its postage, and telegrams, and it struck us how "little this earth with age is wan," when so full of the life and civilisation that now penetrates even to the shores of Assynt. Probably the great geologist's thoughts, on the scene, might have been more appropriate if they had been concentrated on those dawn days of the planet's history, when the waves of the Lower Silurian seas were washing the sand which now constitutes the quartzite of those strata which cap the peaks of Ben More, and Glashven.

CAMBRIAN ROCKS OF IRELAND.

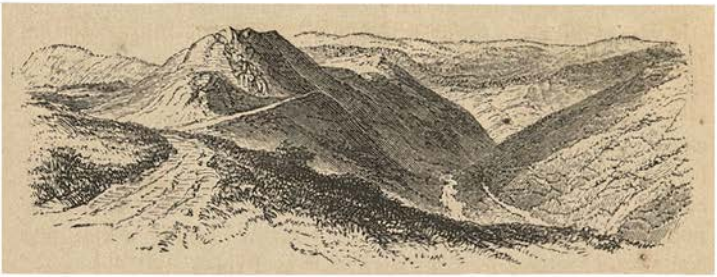
The geology of Ireland does not lie within the scope of these notes, but as so strict a search for organic remains is now going on amongst the Cambrian deposits, it may be well to observe that large rock masses in the northern part of the county of Wicklow; in the Hill of Howth; in county Dublin; and in the mountain-district of South Wexford, are believed to belong to the Lower Cambrian age. A few fossils have been detected, consisting of two or perhaps three species of what is supposed to be a Bryozoon, named Oldhamia by Prof. E. Forbes, after Prof. Oldham; a fossil lobe-worm burrow, showing marks of the tentacles (Histioderma Hibernicum); and lastly, worm-tracks similar to those discovered in the rocks of the Longmynd.

CAMBRIAN ROCKS OF THE LONGMYND HILLS.

The rocks of the Longmynd Hills have long been celebrated as typical of the Cambrian series of strata, and the equivalents of the Harlech, Llanberris, Bangor, and other Cambrian formations in Wales. The hills rise, between Ludlow and Shrewsbury, to a height of 1600 feet, and, in the sections of the geological surveyors, Mr. Aveline reckons that the strata of which they are composed attain a thickness of 23,000 feet.

Near Church Stretton, which is the best locality from whence to visit the Longmynds, the basement or bottom rocks of the series may be seen traversed by greenstone dykes, and we may

follow the beds in ascending order, by the Light Spout Waterfall, Portway, and Ratlinghope, till we arrive at the Stiper Stones, between which and Ratlinghope the Lingula Flags set in. The Longmynd beds appeared at first to be most unpromising ground for the discovery of organic remains, but in the year



VIEW OF THE LONGMYNDS FROM NEAR CHURCH STRETTON.

1846, Mr. Salter, the well-known palæontologist, determined to devote a month to making researches in these old beds, and before a week was gone he detected worm-burrows in sandstone, red slate, grey schist, in fact, in every variety of rock excepting in the fine shales at the bottom, and in the coarse red grits at the top. He was thus fortunate enough to find both limestone bands, and relics of animal life, in the old Cambrian strata. At Callow Hill, Little Stretton, he discovered what he believed to be the remains of a crustacean (Palæopyge Ramsayi). He found also the fossilised burrows of marine worms (Arenicolites), in several localities, at Oakham Dingle, at the Light Spout Waterfall above Church Stretton, and on the west side of Yearling Hill, where, besides these organic remains, he discovered many interesting witnesses of the atmospheric agencies at work, at this vastly remote period of our planet's history, in shore deposits with suncracks, wave marks, and rain drops, thus recording the direction of the wind.

Much doubt has been thrown upon the supposed crustacean, Palæopyge Ramsayi, mentioned above, but as five or six

specimens were found in a limited locality, Mr. Salter never surrendered their claim to be considered as casts of some crustacean.

No beds of lava lie among the Longmynd Hills, but small dykes and protrusions of greenstone occur here and there. The rocks yield a little copper.

The Cambrian beds of the Longmynds are continued into the smaller range of the Haughmond Hills near Shrewsbury, and the exudation of mineral pitch or bitumen from these old rocks is very remarkable. Whence is it derived? Are the rocks charged with animal oil derived from millions of worms, as the bituminous schist of Caithness, and the Alpine schists of Seefeld, owe their bitumen to the extinct remains of countless numbers of fish, or is it, according to M. Abich, a volcanic compound "engendered in the interior of the globe?"

CAMBRIAN ROCKS OF ST. DAVID'S.

Cambrian rocks, resembling those of North Wales and of the Longmynds in Shropshire, were detected by Prof. Sedgwick and Sir R. Murchison in Whitesand Bay, near St. David's, in Pembrokeshire, many years ago. They are also exposed in the northern cliffs of St. Bride's Bay, at the northern end of the Newgale Sands, and at Caerfai, and from thence they range inland.

I had the advantage of visiting the sections of St. David's in company with my friend the Rev. H. Winwood, under the guidance of Dr. Hicks, who has done so much to elucidate the difficult geology of this district, and it was on this occasion that I observed that the so-called Syenite, and interbedded greenstone, formed an axial ridge, *older* than the overlying Cambrians. These are the rocks which may prove to be an extension of the quartziferous breccias and crystalline rocks of the Caernarvon peninsula, and may belong, therefore, to a pre-Cambrian age.

The order of the rocks as determined by Dr. Hicks is as follows:—

	Feet.
8. Menevian rocks, with Paradoxides and many trilobites and their fossils	550
7. Grey flaggy beds	150
6. Grey, purple, and red flaggy beds, with the large trilobite Paradoxides	1500
5. Yellowish grey sandstones, with the genera Plutonia, Conocoryphe, Agnostus, and Theca	150
4. Red flaggy beds, with Lingulella and Leperditia	50
3. Greenish sandstones	400
2. Conglomerates of quartz in purple matrix	60
1. Axial ridge of greenish hornstone and syenitic breccia with bedded greenstones	

The discovery of a Fauna rich in crustaceans in Lower Cambrian deposits is very important, as these formations in the Longmynds, and in North Wales, had been looked upon as nearly barren in fossils. In the rocks of St. David's no less than four distinct species of that fine trilobite, Paradoxides, have been discovered, a genus also found in Bohemia in the lowest strata of the primordial zone of M. Barrande.

It has been argued by no less an authority than Prof. Ramsay, of the Geological Survey, that the red colour in rocks, due to peroxide of iron, which encrusts the sedimentary grains as a thin pellicle, could not have been deposited in an open sea, but rather in an inland salt lake, or lakes.

This red peroxide colours the Cambrian, Old Red Sandstone, Permian, and Triassic rocks, and is believed by some geologists to have been deposited in inland waters, salt or fresh. It has also been said that the Cambrian formations were probably fresh water deposits. It is difficult, however, to accept these propositions, after examining the red beds (No. 4) at St. David's Promontory, which contain Lingulas and Leperditia, besides which, the Trilobites, Conocoryphe Lyellii, and the Paradoxides, have both been found in purple beds, and surely Trilobites were marine animals and not fresh water. As for the supposition that the fossils of St. David's are found only in *grey* beds, which may mark occasional influxes of the sea due to oscillations of level, it was contradicted by the display of a series of fossils by Dr. Hicks, at the meeting

of the Geological Society, May 10, 1871, when numbers of the marine fossils were seen to have been derived from the *red beds* of the Cambrians of St. David's.

It is very difficult to separate the upper beds of the Cambrian series of St. David's from the Lower Lingula Flags. Dr. Hicks is of opinion that the absence of the trilobitic genus, Olenus, from the Menevian group, and its occurrence throughout the whole of the Lingula Flags, and the Tremadoc rocks, together with the fact that, as far as present observations have been made, no genus of Paradoxides ranges higher than the Menevian group, have afforded good palæontological grounds for placing the line of demarcation between the Upper and Lower Cambrians at this point, and for including the Menevian group in the Lower Cambrian series, to the bulk of which it is intimately connected palæontologically (See Geol. Mag. 3 July, 1871).

The best sections to visit are those at Caerbuddy, Porth-y-Rhaw, and Craclli. At Porth-y-Rhaw Dr. Hicks pointed out to us a fine Paradoxides, as large as a fair sized lobster, lying in situ in the rocks along the coast. The modern lobster is also found in abundance along this shore.

We must not omit to direct attention to the interbedded tuff, and lavas, which may be seen intercalated in the strata on the east side of Porth-y-Rhaw harbour, near the beautiful village of Solva. In some places the rocks below the volcanic matter are altered by the overflowing of the lava beds, but these having cooled, the deposition of sediment went on above them and these overlying sediments are unaltered.

East of Porth-y-Rhaw are the Newgale Sands, "at which place," says Giraldus Cambrensis, "during the winter that King Henry the Second spent in Ireland, a very remarkable circumstance occurred. The sandy shores of South Wales being laid bare by the extraordinary violence of a storm, the surface of the earth, which had been covered for many ages, reappeared, and discovered the trunks of trees cut off, standing in the very sea itself, the strokes of the hatchet appearing as if made only yesterday; the soil was very black, and the wood like ebony."

This submerged forest, which is also alluded to in Gibson's "Camden" (p. 635), was again partially laid bare during the winter of 1866, and Mr. Hicks informed me that he had obtained from it at Whitesand Bay, the antlers of a large deer.

Giraldus Cambrensis, the celebrated preacher, scholar, and divine, whose Itinerary, or description of Wales, is often alluded to in this work, was born at the castle of Manorbeer, near Tenby in Pembrokeshire, in 1150. His father was William de Barri, who probably came to England with the Conqueror. His mother was Angarad, daughter of Nest, who was daughter of Rhys ap Teudyr, Prince of South Wales, slain in a battle with the Normans in the year 1090. Giraldus Cambrensis was appointed Legate in Wales by Richard, Archbishop of Canterbury, in 1175, and was shortly afterwards ordained Archdeacon of Brecknock. In 1185, he went with Prince John to Ireland as his Preceptor, and in 1188, he accompanied Baldwin, Archbishop of Canterbury (born at Exeter) on his journey, preaching the Crusades through Wales. His noble and princely lineage proved a bar to his appointment to the Bishopric of St. David's, although he was several times elected, and he made repeated journeys to the Papal court at Rome, in order to induce the Pope to sanction his election to the see. He passed the last seventeen years of his life as a recluse in Wales, revising his works. He died at St. David's in the seventy-fourth year of his age, and was there buried in the cathedral.

At Porth-y-Rhaw, the geologist should not fail to visit the section to the west of St. David's, where the Lingula Flags are partially exposed; but a still better view can be obtained of them by sailing round the Isle of Ramsey. It is a "trough," say Salter and Hicks (Rep. to Brit. Assoc.), a hard rim of Lingula Flag, enclosing Tremadoc, and Arenig (or Lower Llandeilo) rocks.

St. David's itself stands on a range of felspathic rock, marked as syenite by the Geological Survey, but which consists of a grey band with pale crystals of felspar. There is a

section a little north-west of St. David's, where the red grits of the Cambrians, which are exposed on the west of the little brook, are altered by a Trap rock. In fact, at St. David's, at Ramsey Island, and at St. Bride's Bay, igneous rocks are seen in contact with Cambrian deposits of the age of the Longmynd rocks. The Vernal Squill (Scilla verna) and the beautiful maiden-hair fern, are found growing on these volcanic rocks, near their junction with the Cambrians. Again, to the south of St. David's, a mass of volcanic rocks traverses Cambrian strata which trend from a point to the south of St. Elve's, near Brawdy, towards Trafgarn. The Brawdy rocks are granitic, and may be seen in roadside sections in contact with the true Cambrian slates and grits.

Few places are more striking than the isolated and retired situation of the Cathedral Church of St. David's. "Menevia," says Giraldus Cambrensis, "is situated on a most remote corner of land upon the Irish Ocean, the soil stony and barren, neither clothed with woods, distinguished by rivers, nor adorned by meadows." Yet in days gone by, such was the devotion to its Cathedral, that it was esteemed as meritorious to visit St. David's twice, as it was to visit Rome once. "Roma semel quantum bis dat Menevia tantum." Stony no doubt it was in the days of Giraldus, for until of late years, the country round was actually covered by trap boulders, transported from the adjacent rocky hills which run from St. David's across the country to the Precelly Hills. These boulders were formerly scattered all over the district, as I learn from Mr. Davis of Trewarren, who remembers their great abundance before they were used in building walls, and before the country was as much cleared as it is at present. My opinion is that these boulders are all local, and have travelled over a slope of ice and snow which once reached from the Trap Hills of Precelly down to the sea.

Giraldus gives farther details respecting St. David's. He says that "Dubritius of Caerleon, sensible of the infirmities of age," resigned his honours to David, who is said to have been uncle to King Arthur, and by his interest the see was

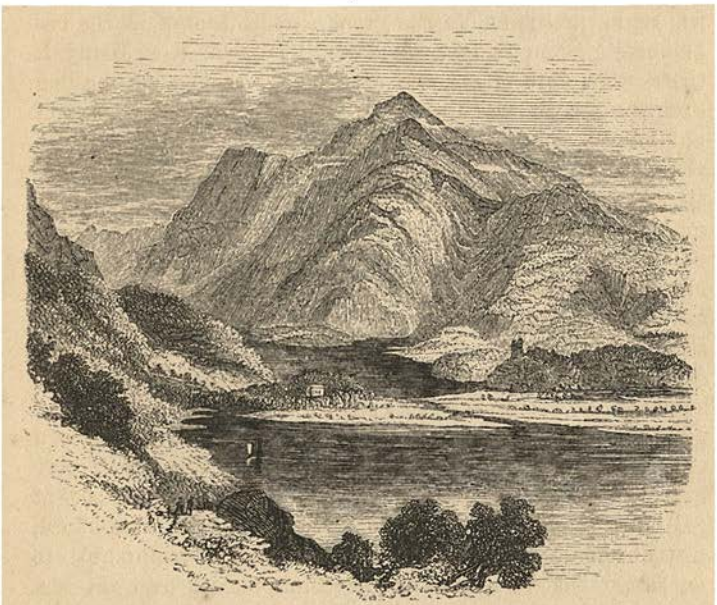
translated to Menevia, although Caerleon was much better adapted for the episcopal see.

David was remarkable for his sanctity and religion, and among the many miracles recorded of him three appeared to Giraldus "most worthy of admiration, his origin and conception, his pre-election thirty years before his birth, and what exceeds all, the sudden rising of the ground at Brevy under his feet while preaching, to the great astonishment of all the beholders." From the time of David to that of King Henry I. there were numerous archbishops and bishops who presided over the see, of whom one "Morgenan," the first Bishop of St. David's who ate flesh, was there killed by pirates. He appeared to a certain bishop in Ireland on the night of his death, showing his wounds, and saying, "Because I ate meat, I am made meat." "The spot where the church of St. David's is built, is called the Vale of Roses, which ought rather to be named the Vale of Marble, since it abounds with one and by no means with the other." Giraldus also describes the visit of Henry II. on his return from Ireland, and his passing over a stone polished by continual treading of the passengers; how he proceeded "towards the shrine of St. David, habited like a pilgrim, and leaning on a staff, he met at the White Gate a procession of canons of the church coming forth to receive him with due honour and reverence. The King supped at St. David's, and then departed for the Castle of Haverford, distant about twelve miles." It appeared very remarkable to Giraldus "that when David the Second presided over the see, the river should have flowed with wine, and that the spring called *Pistyll Dewi,* or the pipe of David, from its flowing through a pipe into the eastern side of the churchyard, should have ran with milk."

The Cathedral is built principally of Cambrian sandstone which has weathered a good deal. In the chancel is the tomb of Edmund Earl of Richmond, father of King Henry VII., and a monument to Rhys-ap-Gruffydd, the Prince of South Wales, who as we shall presently see showed great hospitality to the Archbishop of Canterbury, and Giraldus Cambrensis, and died in 1196.

LOWER CAMBRIAN ROCKS OF NORTH WALES.

The Cambrian rocks of Llanberis, Dolbadarn, and Nant Francon are supposed with good reason to be the equivalents of the Longmynds in Shropshire, and of the series at St. David's in Pembrokeshire, with which they were doubtless once continuous.



PASS OF LLANBERIS, FROM THE LOWER LAKE.

By tracing up the sections we find near Dolgelly, Menevian beds containing Paradoxides, and we pass on into the overlying strata which belong to the period of the Lingula Flags. Llanberis is an admirable locality for the physical geologist who intends to examine the Cambrian formations of North Wales, and the antiquarian also will find many interesting records of days gone by in the ruined castles and noted places of the neighbourhood. The old castle of Dolbadarn is a ruin

worthy of the ancient rocks on which it stands, for it is believed, on good authority, to have been built by Cambrians as early as the eighth or ninth century. It fell into the hands of Owen Glyndwr during his warfare against the English, and during the reigns of Henry IV., and Henry V., it was at one time in their possession, and was then again retaken by the Welsh. It had already become a ruin in the time of Henry VIII., for when Leland visited Llanberis he describes Dolbadarn as only possessing "a pece of a tour, where Owen Gough, brother to Llewellyn, first prince, was in prisn." We here see the Cambrian conglomerates and slates which form the basement rocks of Snowdon, ranging on both sides of this old castle of Dolbadarn. The rocks in the upper beds consist of greenish grey grits, underneath which lie the purple slates of the Llanberis quarries, and these again pass downwards into the conglomerates of Llyn Padarn, which themselves abut against the porphyritic rock of Llanllyfni. Near the copper mine above the lake Llyn Peris, "close to the small octagonal building marked 'office' on the Ordnance Map," Professor Ramsay* directs attention to "a glaciated surface of hard Cambrian grit, and striations running down the valley, as fresh as if the ice had but lately disappeared."

The Lower Cambrian beds are traversed by porphyritic quartz rock which may be seen at Llyn Padarn, and again at Moel Gronw, where a porphyry appears to have been injected over, and to be interbedded with, the Cambrian strata, in the same manner that the Basalts of Auvergne sometimes overlie and are interbedded with strata containing the remains of fresh water plants and animals.

The best sections are in the passes of Llanberis and Nant Francon, the latter, which is on the Ogwen, between Nant Francon (the Beaver's Glen) and Bangor, is more simple and more easy to work out than the Llanberis sections. The walk from Cwm-grainog to the neighbourhood of Llyn Coron, across the Penrhyn slate quarries, furnishes a section from the Cambrians of these quarries to the base of the Bala beds. The

* "Ancient Glaciers of Wales."

reading off of these faults is excellent practice for the physical geologist. These celebrated slate quarries of Penryhn are among the wonders of North Wales, and they yield an annual average of 120,000 tons of slate.

At Cwm Grainog (the Stony Valley) we see the relics of a small glacier, and we also find another instance of these remains at Cwm Bochlwyd, under the Glyder-fawr. Here, too, is a romantic tarn containing the Torgoch, or Welsh char. There is a fine moraine at the upper end of the Tarn with well-marked roches moutonnées, and in the glen are several blocs perchés.

The relics of former glaciers are very striking round Llyn Idwal, and the range of the Glyder precipices are among the most remarkable in Snowdonia. Roscoe describes Trifaen, the northern spur of the Glyder-fawr, as like "some huge monster with human aspect strangely distorted, scowling upon the Carnedd y Gwynt, or Hill of Storms."

Llyn Idwal itself is said to have been the scene of the murder of Idwal, one of the princes of North Wales, who was flung over the precipice, his death-shriek and yell of mortal agony still ringing in the thunder storms which so often rage round the bold rocks which rise precipitously above the loch.

It was down the old glacier track of Llyn Idwal that I was led, some years ago, by William Williams, the once celebrated botanical guide of Snowdon, and on the precipices of the Glyder I saw him gather two specimens of the rare Spider-wort (Anthericum serotinum).

The town and neighbourhood of Caernarvon present points of great interest both to the antiquarian and to the geologist. The town is a place of great historical interest, and was very early distinguished in the ancient annals of Wales. The Roman Segontium stood at Llanbeblig, about half a mile from Caernarvon, on the Beddgelert road. It was a stronghold of great celebrity, and occupied a space of about seven acres. It is mentioned by Antoninus in his Itinerary, and is said to have been the birthplace of Con-

stantine the Great. Numerous Roman relics, such as coins, tiles, and portions of a hypocaust, have been excavated on the site of Segontium.

Caer Seiont was the old British name for Caernarvon, but the place had assumed its present title in the days of Henry II., for Giraldus Cambrensis speaks of "having passed through Caernarvon, that is the Castle of Arvon, the province opposite to Mon, because it is so situated with respect to the island of Mona" (Anglesea).

For the geologist, one of the most interesting features in this district will be Moel Tryfaen, with the Cambrian rocks underlying the Boulder drift on its summit.

It was on a glorious summer morning in 1863 that I set out from Caernarvon, with Sir Charles Lyell, to examine these Cambrian rocks, and to search for the Boulder drift which had been discovered on Moel Tryfaen, in 1831, by Mr. Trimmer, and in which he had found specimens of fossil shells. We first proceeded to Nantle, where we examined the quarrying and mining of Cambrian slates. There is also a slate quarry on the southern side, near the summit of Moel Tryfaen, which is spoiled by a Trap dyke. The rocks on the summit of the hill are Cambrian conglomerates, caught up amongst traps and volcanic rocks, and thus elevated to the surface. The conglomerates lie at the base of the Cambrian slates.

The Alexandra Mining Company had opened a section thirty-five feet deep in the drift near the summit of the hill on the north side, and we thus had a fine opportunity of seeing a splendid section of drift, well stratified, resting on vertical Cambrian slates, and containing in the lower gravel beds large boulders of transported rocks, glacially polished, striated, and scratched. We collected several nearly perfect specimens of fossil shells from the drift in situ, and obtained others from the workmen; while Mr. Darbishire has formed a collection of no less than fifty-four species of shells from this elevated drift. Mr. Gwyn Jeffreys determined that all these Mollusca are now living in British and northern seas. The highest level of the shell-bearing drift is 1360 feet.

Sir Charles Lyell* alludes to the unusual preservation of shells in porous drift, like that of Moel Tryfaen, and to the suggestion of Mr. Darbishire, that they were preserved by a clay bed, one foot nine inches in thickness, which underlies the surface soil, and by its impermeable nature protects the drift with the shells. I would particularly recommend this pan of clay to the attention of future explorers! We attributed its existence to the effect of land ice and snow, which swept down for a long period from the higher hills around, and deposited the clay over the upraised sea bottom. There are also numerous fragments of local rocks scattered among the surface soil of Moel Tryfaen, *local boulders*, in fact, overlying the clay band, and which were also, I imagine, transported to the places they now occupy by the aid of the land ice and snow, which, in all probability, covered the whole of this district for many a long year after Moel Tryfaen with its marine drifts had been elevated to its present height. These boulders are very different from those deposited at the base of the gravels and sands; for these latter lie in a mass of boulder clay, and consist of large grooved and rubbed boulders. They are for the most part erratics from a distance, and not local boulders from the hills around. Among them we saw a black mass of basalt, which I believe must have travelled all the way from Ireland, with granite from Scotland, or Cumberland, and a dark porphyritic rock that does not belong to Wales, as far as I know.

Nowhere do we possess more undeniable evidence of the submergence of large portions of Great Britain beneath the glacial seas than among, and around, those old Cambrian rocks of which we have been treating. Glacial drift with erratic boulders, and containing marine shells, is elevated to the height of more than 2000 feet in some localities on the flanks of the mountains. These shells are all of existing species, many of them identical with those living in our seas, mingled with others of more northern habitats, and which frequent seas of colder temperature. Such are the drifts on Moel Tryfaen, five

* "Antiquity of Man," p. 528 (3rd ed.)

miles east of Caernarvon, which occupy a height of nearly 1400 feet; and the drifts around the Maenbras, and its companion local erratics, which rest on drift with shells, and which may be seen near the little lake Ffynnon-y-gwas, two miles west of the peak of Snowdon.

These drifts also lie on the westward flanks of Carnedd Dafydd, and Carnedd Llewellyn, and they rest on those upheaved mountains at a height of more than 2000 feet.

No one should visit this interesting district without being accompanied by Prof. Ramsay's "Ancient Glaciers of Wales." With this as a guide it is impossible to avoid arriving at the conclusions so admirably worked out by the Professor. Many a long summer's day have we spent in tracing out the proofs he has brought forward: first, of the submergence of this mountain land, and the deposition in its valleys, and depressions, during the period of its submergence, of drift containing marine shells. These drift deposits rest on boulder clays, and large foreign erratics, probably stranded by icebergs. Then we have evidence of the elevation of land to its present height above the sea, and with the elevation of land came the elevation of the drifts. Again, *since* the land was upraised to its present position, there are proofs that large glaciers swept down the vales, and ploughed out the drift and its marine shells; but leaving here and there patches and outliers of it, to certify of its former existence. There is a splendid example of these occurrences at Cwm Llofai, on the western side of Carnedd Llewellyn; and another between the hills of Yr Elen, and Mynydd-die, where a small glacier, two miles in length, has ploughed out a long narrow hollow in the drift. There is also proof that the great glaciers became gradually reduced in size and were succeeded by smaller glaciers.

This is but a poor and brief résumé of the glacial wonders to be seen among these rocks of Cambria, but words cannot depict the history! The records themselves must be studied on the hill side, by the lake, by the stream, and in the glen.

Bangor.—Leland, from the chronicle of John Harding, states that Condage, a British prince, erected a temple at

Bangor, which he dedicated to Minerva. The historian Cressy places the date of the Cathedral in 516, and informs us that St. Deiniol was the first bishop. The cathedral was destroyed by the Normans in 1071, but was soon rebuilt, for Giraldus Cambrensis mentions that Archbishop Baldwin and his followers "were entertained by the bishop of the diocese" in 1187. When King John invaded Wales, A.D. 1210, he made the bishop, Robert of Shrewsbury, pay a fine of 200 *hawks;* which hawks, or peregrine falcons, the bishop is supposed to have obtained from Stackpole rocks, near Pembroke.

Owen Glyndwr destroyed the cathedral again in 1402, and for ninety years it lay in ruins, after which time the present edifice was raised, built principally of the perpendicular work of the 16th century.

Bangor is near at hand to some of the finest scenery in North Wales, and it is a good place whence to make excursions and examine Cambrian sections.

To the west of the Penrhyn Arms, at Bangor, are altered Cambrian rocks, consisting of green and purple grits, conglomerates and slates, closely resembling the lower beds of the Longmynds, near Church Stretton, and they rise from underneath strata containing fossils. These metamorphosed Cambrians are not, however, in the least like the metamorphic rocks of Holyhead.

The Bangor rocks were long ago correlated with the Longmynd rocks by Prof. Sedgwick, and some of the slaty beds at Perfeddgoed are very like those slaty rocks, over the Channel, at Bray Head, in Ireland, which contain the supposed Bryozoon, Oldhamia antiqua. Years ago, when geologizing with my friend, the Rev. Reginald Hill, over this district, we were struck with the mineralogical similarity between some of these greenish and purple Bangor beds and an Oldhamia slab from Bray Head, which I had with me.

North of the Ogwen, near Llanllechia, is a section which displays the rocks in ascending order, from the conglomerates at the base to the Lingula Flags, near Bethesda. Worm tubes occur in the sandstones of Moel-y-ci,

FOSSILS OF THE LOWER CAMBRIAN ROCKS.

Formerly the Oldhamia of Ireland, some burrowing worms, (Histioderma), and the crustacean Palæopyge Ramsayi, constituted the whole of the organic remains found in the Lower Cambrian deposits. Now, thanks to the discoveries of Dr. Hicks, in Pembrokeshire, the equivalents of the Harlech grits have yielded highly organised trilobites, such as the Plutonia, and Paradoxides. Altogether a rich fauna of trilobites, brachiopods, phyllopods, and pteropods, has been discovered, showing that the Cambrian seas, once considered azoic, or lifeless, nourished many animals of by no means a low state of organization.

The Menevian beds which pass into the Lingula Flags are separated from the overlying deposits on purely palæontological grounds, for I do not think it is possible to draw any line on physical data, and it appears that the most characteristic genera in these strata are unknown in the Lingula Flags proper. Such are the Trilobites Paradoxides, Conocoryphe, Erinnys, Anopolenus, and Plutonia. It is supposed that these crustacea swam on the surface of the waters and fed on minute marine animals. Some of the trilobites of the Lower Cambrians appear to have been blind, others possessed highly developed eyes.

M. Barrande has traced various transformations like those undergone by existing crustaceans in no less than twenty species.

The Thecas found in these beds are the oldest Pteropods yet discovered.

The additions made to the fauna of the Lower Cambrians (Longmynd and Menevian groups) by Dr. Hicks's researches, now number about fifty species, belonging to twenty-two genera, as follows—

Trilobites	10 genera	and	30 species.
Bivalved and other Crustaceans,	3 genera	,,	4 species.
Brachiopods	4 genera	,,	6 species.
Pteropods	3 genera	,,	6 species.
Sponges	1 genus	,,	4 species.
Cystideans	1 genus	,,	1 species.

UPPER CAMBRIAN ROCKS OF LYELL, PHILLIPS, AND SALTER.

(Lowest Silurian rocks of Murchison and Ramsay).

3. Tremadoc Slates	Niobe Homfrayi. Angelina Sedgwickii. Asaphus affinis. Cheirurus Frederici.
2. Upper Lingula Flags.	Olenus humilis. Olenus alatus, Olenus pecten. Orthis lenticularis. Dictyonema sociale.
1. Lower Lingula Flags, passing into	Hymenocaris vermicauda. Olenus micrurus. Lingulella Davisii.
Menevian Beds . .	Agnostus. Theca. Paradoxides, &c.

a, Grits and Schists; Cambrian (Longmynd) Rocks. *b*, Lingula Schists, with imperfect transverse Slaty Cleavage.

The name of Lingula Flags was given to this group on account of the abundance of Lingulæ found in some of the beds. The Lingulæ were first discovered in 1845, near Tremadoc, by Mr. Edward Davis, of Presteign. In Merionethshire, in the neighbourhood of Barmouth and Harlech, masses of slaty rocks, nearly 5000 feet in thickness, are seen to immediately overlie the Lower Cambrian rocks. These are the Lingula Flags of Professor Sedgwick, the first geologist who described their position and mineral character in Wales. The Lower Lingula Flags are generally blue slaty beds, stained with oxide of iron. They occupy the district between the Cambrian rocks of Barmouth and Harlech, and the interbedded Llandeilo and Igneous rocks which run by Cader Idris, the Arans, Arenigs, and Moelwyn, round to Ffestiniog, and here they consist of coarse, greenish coloured, quartzose grits, and are

probably derived from the denudation of such quartzose and granitic rocks as constitute the west coast of the Lleyn promontory, and Anglesea. There are also purple strata graduating downwards into thick masses of purple and greenish slates. Similar beds in Shropshire are full of worm tubes. The junction of the Menevian beds, and Lingula Flags, with the underlying Lowest Cambrian rocks, may be seen at Aberramffroch, near Barmouth, the mineralogical differences at once marking the junction. Barmouth is a favourite spot for the headquarters of a geologist. It is situated on the Mawddach, or Maw, and at the mouth of the river is the "Friar's Island" (Ynys y Brawd), noticed by Leland, "At the north of the Maw ryver lyeth a little islet, scant a bowshot over, without habitation." Ten miles from Barmouth is the ancient town and castle of Harlech, which every traveller, however wanting in taste for natural history, should pause to see, if only for the sake of beholding one of the finest sea views in all Cambria, and of visiting the noble ruins which have withstood many a siege from the days of Bronwen, the white-necked sister of Bran ap Llyn, King of Britain, down to the last struggle in Wales for the luckless Charles I.

It is also recorded in the history of the Gwidir family, that in the reign of Edward IV., William, Earl of Pembroke, "wasted the mountaine countreys of Caernarvon and Merioneth," and a Welsh rhyme thus describes the devastation—

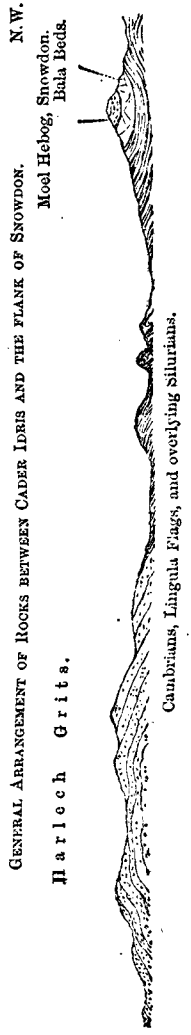
Harlech a Dinbech poldor
Yn Cunneo
Nan Conway yn farwor
Mil a phedwar cant mae Jor
A thugrain agwyth ragor.

"In Harlech and Dinbech every house
Was basely set on fire,
But poor Nant Conway suffered more
For there the flames burnt higher."

The Harlech district, as regards the Cambrian rocks, is that which lies between the Barmouth estuary and that of Traeth Bach, and the Harlech grits are the lower Cambrians which

pass upwards into the Lower Lingula Flags. The castle of Harlech stands upon a precipice of Cambrian rock, and it is difficult to understand by what possible process of mineralogical metamorphism the Harlech grits could be converted into the crystalline granitic rocks which strike along the west coast of the opposite peninsula of Lleyn. A new genus of Trilobites, called Plutonia Sedgwickii, has been discovered in the Harlech grits. It is nearly as large as the great Paradoxides Davidis, with large eyes and tuberculated.

The centre of the great Merionethshire anticlinal, thus termed by Professor Sedgwick, who was the first to elucidate the puzzling structure of the mountains of Wales, is at Gorsgoch, north of the Llawlech Hill. The central boss of Cambrian rock throws off the Lingula Flags all around. The Merionethshire anticlinal is a series of great curves, anticlinal and synclinal, of which the Barmouth and Harlech sandstones form the base. The great Diphwys range, forming a serrated crest of twelve miles long, is perhaps more generally intelligible. While speaking of this district we cannot but recommend every one who wishes to see a complete and beautiful section of the lower Cambrian grits and slates across the great Anticlinal, to pass over the moor from Trawsfynydd and to penetrate the romantic gorge of Cwm Bychan. Not only will he see the full succession of the grey and green grits contorted and thrown into broken curves, but the pass itself is most remarkable. For miles the Romans have laid down the great square Cambrian slabs quarried from



GENERAL ARRANGEMENT OF ROCKS BETWEEN CADER IDRIS AND THE FLANK OF SNOWDON.

the pass, in an enduring pavement, terraced from west to east. This pavement continues all through the most rocky part of the gorge. Cwm Bychan, and the valley to Llanbedr, is also a good locality for the study of glaciated rocks, moraines, perched blocks, and other phenomena appertaining to a glacial epoch long since passed away.

Dolgelly lies in the midst of a charming district for the naturalist. There is little of interest about the town itself, but its proximity to Cader Idris and the adjoining mountains is a great attraction to the lover of the older rocks. Near Dolgelly are first-rate sections of the Lingula Flags; those in the neighbourhood of the gold mines, and of the waterfalls, will naturally be preferred by the geologist as they contain the promise of abundant fossils. That large Menevian Trilobite, *Paradoxides*, has been found by the waterfalls of the Mawddach valley, on the brow of the hill just above the lead mines of Tyddyngwladis.

The most instructive section is that on the line of country from the Cambrian rocks of the Llawllech, by Y Fron-Henlog to the estuary; and again from Coedd y garth, east of the estuary, across the interbedded traps and Lingula Flags of Lyn-yr-Wylfa.

Eastward the ranges of Moel Hafod Owen, and the high pleasure grounds of Nannau on the left banks of the Mawddach, show excellent sections. These strata are conspicuous near the town, but the best route to take in order to examine the whole series, is to follow the course of the Mawddach river from the gold and lead mines at the waterfalls, up to the higher forks on the east.

Lingula Flag fossils may be found in the same region at Gwern-y-Varcyd and Moel Hafod Owen, and among them is the shrimp-like crustacean Hymenocaris. At Dolyfrw-Ynog the Lingula Flags are altered into a talcose schist by a volcanic rock which is probably a spur from the great mass of greenstone, Rhobell-fawr. Cwm-eisen gold mine is in hard flags of the Menevian and Lower Lingula group, and the manner in which strata have been disturbed by faults may be seen by walk-

ing along this great quartz vein, which is full thirty feet broad and broken into a dozen fragments, some of them yards apart, others hundreds of feet asunder. The gold lode lies in an ancient fissure, itself a fault, which has again been fractured and broken up.

Gold mines are abundant in this neighbourhood, if the inhabitants are to be trusted. More than one person in Dolgelly offered to sell me "a digging" where a large fortune was "sure to be made by those who could afford to advance the capital necessary for the undertaking;" but from what I know of these gold mines I have no faith in Welsh gold, inasmuch as the precious metal occurs only on the surface, and dies out when followed into the heart of the rock. There are one or two points worthy of observation with respect to these gold-bearing rocks of Wales. First, that gold has rarely been found excepting in the neighbourhood of trap rocks; secondly, that it appears to have been formed in the crevices, veins, and interstices of quartz veins; and thirdly, that the quartz veins and the gold have been infiltrated into the Lingula Flags and other Cambrian rocks, after the cooling and consolidation of the trap, and when the trap and sedimentary deposits were alike beneath the sea.

Trawsfynydd, a village on the road from Dolgelly to Tan-y-bwlch, is a place of interest both for the geologist and the antiquarian. On the south-west of Ffestiniog near Trawsfynydd, runs the fault which throws down the Cambrian rocks on the east, against the Lingula Flags. It is a good locality from whence to observe the curving towards the westward of the Cambrian rocks, and the throw of a fault which has been calculated by Prof. Ramsay, to be 2400 feet.

Fossils in the Lingula Flags are found in abundance on the road from Ffestiniog to Bala and Bedd Porws; indeed, besides having been celebrated by various authors for its lovely Welsh scenery,* Ffestiniog has long been famous for fossils characteristic of this group.

* The "Ffestiniog group" of the Dolgelly district is well described by Mr. Thomas Belt, F.G.S. See Geol. Magazine, Vol. IV. (1867), p. 493, &c.

South of the river every quarry contains them, and by going from Ffestiniog to Maentwrog, and thence south to Tafarn-helig, close to the great fault an entire section may be traced. That fine trilobite the Paradoxides Davidis, which in Pembrokeshire is characteristic of the Menevian beds, has been discovered by Mr. Homfray, at Tafarn-helig in the black slate by the brookside, accompanied by many other trilobites of the Menevian and Lingula Flag groups, such as the Conocoryphe, Agnostus, &c., and with them was associated a large Theca.

Above these are dark grey slates, or true Lingula beds, with many small specimens of Lingula Davisii and Agnostus princeps. At Caen-y-coed and the Waterfall, Velyn Rhyd, on the river, the strata, greatly squeezed, are full of crushed specimens of Agnosti. Crossing the river, we ascend in the section; at Tan-y-bwlch, the strata are higher in the series than those at Maentwrog, and close to the hotel is a quarry, where they contain many Lingulæ. But this is not all; the geologist must ascend the heathy brow of the hill above the hotel, hammering as he goes, for the rocks are rich in fossils, and he should find Hymenocaris in the bluish slate on the top of the hard flags.

On the line of railway we come at once upon the Upper Lingula Flags, an intensely black band. It appears as if the railway were excavated along the length of this band, for it follows it for some distance. The beds contain trilobites, and the net-like Dictyonema.

Ffestiniog is an excellent locality for the botanist. The ferns Hymenophyllum Tunbridgense and H. Wilsoni, grow near the pulpit rock on the falls of the Cynfael.

Near Ffestiniog, at Bedd Porws, we also find a Roman grave, on which is a very ancient inscribed stone. The following notice respecting this stone is given by Gibson, in his additions to "Camden's Britannia:" "I am told there are also a considerable number of graves near this causeway on the Demeans of Rhiwgoch, in the parish of Trawsvynydh, and in the year 1687 I copied this inscrip-

tion from a stone called 'Bêdh Porws,' or Porus' grave, near Lhêdch Idris :

"PORIVS
HIC IN TVMVLO JACIT
HOMO RIANVS FVIT."

Rianus was supposed to stand for Christianus, but there was never any room between Homo and rianus for the syllable *chris*.

The stone is probably of the same date as the "Maiden Stone," which like "Porwy's Grave," stands near the old Roman road, Sarn Helen, as it passes from Gaer Bannau towards Brecknock. Castell Prysor is a Roman fort where Roman coins and funeral urns have been found. It stands on a scarped hill of rock, but there is little left of the remains of buildings, or of the relics of human handiwork. Sir R. Colt Hoare describes another Roman inscription, from Tonnon-y-Mur, (or the Tumulus in the wall,) so named from a large mound within an encampment at the Roman station of Heriri Mons, through which the Sarn Helen road passes. This inscription is preserved at Tan-y-bwlch Hall. From Heriri Mons, a Roman road of communication to the vale of the Conway passes by Dolwyddelan Castle.

Camden says of this road, "There is a high road, or military way of pitched stones, which leads through these difficult and almost unpassable mountains; and seeing it is called in British, Sarn Helen or Helen's Way, it is but reasonable that we suppose it made by Helena, the mother of Constantine the Great, whose works were many and magnificent throughout the Roman Empire."

In the Snowdon Country, the Lingula Flags may be seen in the Pass of Llanberis, resting on Lower Cambrian beds on the sides of Llyn Peris, and rising into the ridge of Elidyr-fawr. On the north of this hill they dip at high angles into Marchlyn-mawr, where Lingulæ and Olenus have been found. The geologist stationed at Llanberis should take the route from thence, ascending Cwmdudodyn, and passing down Moel

Perfedd to the stony valley, or Cwm-grainog. Moel Perfydd consists of a felspar porphyry, and on the west may be seen grand sheets of rippled rocks, the Lingula beds dipping downwards and eastward into the Cwm at an angle of 60°. We have already described this Cwm-grainog with its old moraines filled with pieces of scratched rocks, shed from the edge of the glacier as it passed from one side of the valley to the other. On the eastern side of the valley, the fragments are derived from the felspar rock of Moel Perfedd, while on the western side, the moraine matter consists of fragments of Lingula Flags, which form the rocks of Carnedd-y-filiast. Here also are fossils, for I found a worn Lingula among the moraine detritus, and worm tubes, such as Scolites; while Cruziana semplicata occur in the rippled marked Lingula slates, and Cruzianæ of large size lie heaped among the broken flags at the base.

In many localities near Bangor, the Lingula Flags, highly inclined, rest on Cambrian grits; this may be observed beyond the great Penrhyn quarries. They are black slates, containing Lingulella Davisii, the Cruziana, and an Olenus.

It is worthy of remark that the Lingula Flags do not cross the Menai Straits, so that the Llandeilo, or Bala beds, rest unconformably on the so-called Cambrian rocks of Anglesea. The same remarks apply to the Caernarvonshire peninsula of Lleyn, where the crystalline rocks classed as Cambrians occur also. I have before stated that it has long been my opinion, which as an amateur I trust I may hold without presumption, that the Anglesea and Bardsey rocks, called Cambrians, are *not* of the same age as those of Barmouth, Harlech, Llanberis, and Bangor, but are older Pre-Cambrian masses, which were elevated into dry land during the period when the Lower Cambrians, and Lingula Flags, on the other side the straits, were accumulating; and that after the Cambrian epoch had passed away, the old Pre-Cambrian rocks were submerged, and the Llandeilo and Bala beds were deposited upon them, the true Cambrians, and Lingula Flags, being unrepresented either in Anglesea, or Lleyn.

LINGULA FLAGS OF SHROPSHIRE, HEREFORDSHIRE, AND THE MALVERN HILLS.

The Stiper stones of Shropshire were ranked by Sir R. Murchison with the Lingula Flags of Wales, but it appears from the "Memoirs of the Geological Survey" (vol. iii., p. 257) that this narrow band of quartzose rocks is now classed with the Lower Llandeilo formation, the true Lingula Flags lying beneath them, and being represented by the earthy shales between Ratlinghope, and the Stiper stones. In Herefordshire, at a place called Pedwardine, there is an upthrow of the Upper Lingula Flags through the Wenlock shale of Brampton Bryan Park. Here I was conducted some years ago by Mr. Lightbody of Ludlow, and at once recognised the Dictyonema* shales of the southern end of the Malvern Hills. The shales of Pedwardine afford a small Lingula, as well as the Dictyonema sociale, a peculiar net-like fossil allied to the graptolites.

Lingula Flags of Malverns. For a long period it was hoped, for the sake of antiquity, that the Hollybush sandstones of the South Malverns, were the representatives of the Lower Cambrians of North Wales and the Longmynds. They are now, however, known to be of Upper Cambrian date, for they lie below the *Black Shales*, which the researches of Phillips, Strickland, and Barrande had ascertained to be primordial in character, and, in a general way, of the age of some part of the Lingula Flags. Professor Phillips did not find any fossils in the Hollybush sandstones; but Dr. Grindrod has obtained a good series of worm tubes, and being thus in the situation occupied by the Middle Lingula Flags, Mr. Salter suggested to us some years back that these sandstones were of that particular period. Dr. Holl has endorsed this opinion, and he has found a number of minute fossils in them which support this view. These greenish, sandy, thickbedded rocks, may be seen in a large quarry on the high road from Ledbury to

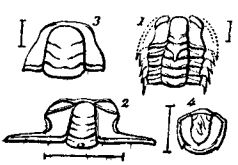
* This fossil occurs also at Bronfoel, near Tremadoc; at Tan-y-bwlch, and near Ffestiniog.

Tewkesbury, near the summit of the Hollybush pass on the Eastnor side. Again they are exposed at the great quarry of the White Leaved Oak, between the Ragged-stone and Chase-end hills to the west of the Hollybush pass. The quarry is worked in a hornblendic greenstone.

These greenish sandstone beds are overlaid by Black Shales which, as in Wales, have furnished several fossils characteristic of the Upper Lingula Flags. Among them are several species of the small Trilobites, Olenus, such as O. scarabæoides, O. alatus, O. pecten, O. humilis, the Agnostus trisectus, and the Obolella Salteri. In certain grey shales which *overlie* the Black Shales, and are seen along the south-western flank of the Chase-end hill, and to the south of Pendock Grove, I was fortunate enough to discover the characteristic Dictyonema sociale, a bryozoon, always found at the top of the Upper Lingula Flags, and to correlate the position of these Malvern rocks with those of North Wales.

In order to prevent disappointment at not finding fossils in these Black Shales of Malvern, it may be well to mention that it is a good plan to carry away portions of the shales, to wash them carefully one by one, or, better still, to expose

TRILOBITES FROM THE BLACK SCHISTS OF THE MALVERNS.



1, Olenus humilis, Phillips.
2, O. bisulcatus, Phillips.
3, Olenus scarabæoides, Wahl.?
4, Agnostus pisiformis, Linn.

them to the frost for the purpose of splitting them. Miss Margaret Lowe of Malvern has done this for many years, and, indeed, all who have been successful investigators have found weathering the shales or drying them at a fire to be almost necessary to the detection of their minute though most interesting fossils.

The volcanic rocks, associated with the Black Shales, are highly interesting. Bands of volcanic grit and felspathic trap traverse, but only slightly alter the shales, as seen between the White Leaved Oak, and Fowlet's Farm ; and these traps, full of gas cavities, like ordinary lavas, are interbedded with the Black Shales which have been denuded ; and thus the harder volcanic bosses are left standing out from the softer strata. There is a beautiful little section in a field below Coal Hill, west of a small cottage in the dingle, where baked shales and augitic lava are exposed in layers.

There are also four bosses of a similar volcanic rock near Bronshill Castle, at the base of the Obelisk Hill, Eastnor.

TREMADOC ROCKS.

These strata, now that the fossils which they contain have been worked out and fully known, are by common consent allowed to constitute the uppermost rocks of the Primordial Zone, or Upper Cambrians. The Lingula Flags can hardly be visited in the Portmadoc district without meeting with this little-known but prolific formation.

The discoveries of Mr. David Homfray and Mr. Ash have enabled the Geological Surveyors to separate the underlying Lingula Flags from the overlying Tremadoc strata, and to divide the latter group into upper and lower Tremadoc Slates. The position of these strata and their superposition to the Lingula Flags was determined by Professor Sedgwick in 1846. There is a peculiar band of pisolitic ore, and in this we find a commingling of Silurian types of fossils with those which M. Barrande termed "Primordial."

Mr. Salter, who carefully examined the ground, told me repeatedly that he believed the Tremadoc epoch followed more closely on that of the Lingula Flags than is generally supposed, and that the intervention of Tremadoc rocks, containing a remarkable assemblage of fossils, "indicates that the epochs of the deposition of the Llandeilo strata were separated from all the Upper Cambrians by an enormous period of time ;" and that a strong line of demarcation must be drawn between the Tre-

madoc, and Llandeilo periods. Very few of the Tremadoc fossils are found in the Lingula Flags below, and none in the Llandeilo Flags above. It is this remarkable break in the succession, not only of species, but of genera, which induces Prof. Ramsay to believe that there is an actual unconformity in this part of the series of the older Palæozoic rocks, and it is certain that the Tremadoc group is much overlapped by the Llandeilo strata.

Across the Penrhyn promontory, between Traeth Bach and Traeth Mawr, the strata may be traced in ascending order, from the Upper Lingula Flags through the Tremadoc group, to the Lower Llandeilo strata at Garth Hill.

There is also a fine section at Y Graiggdder, a promontory east of Criccieth; and another in the Tremadoc district on the road running from Portmadoc to Treflys, where the lower dark shaly Tremadoc slates may be seen to overlie the darker coloured pyritous Upper Lingula Flags. Again the same beds are seen at the village of Penmorfa, where they are full of fossils. Another section of these rocks occurs along the west flank of Moel-y-gest. The upper slates are light coloured flinty beds intercalated with layers of volcanic ashes, and are to be seen overlying the Lower Tremadoc slates on the west side of Portmadoc harbour, and at the rock Trwyn Cae Iago, east of Borth. The west side of Moel-y-gest, Borthwood, and Aber-ia, are good localities for finding the fossils of the Lower strata, as are the Portmadoc quarries and the north side of the Penmorfa marsh for the fossils of the Upper beds. But the best of all localities is at Garth Hill across the Traeth Bach, where Messrs. Homfray and Ash, and the officers of the Survey, have collected thousands of specimens.

It is perhaps one of the most exciting moments to the geologist, while sedulously tracing the bed of a well-known formation, and noting its organic contents, to come upon a new formation, a tract of strata doubtfully grouped before, and believed to be barren of traces of life. Such was the reward of the first explorers of the Tremadoc rocks which suddenly, as it were, yielded a rich strata of new organisms, allied indeed to

the forms of life in the rocks above and below them, but with new and distinct modifications of shape and structure.

The Tremadoc rocks in their typical district near the town of Tremadoc, and all around the course of the Ffestiniog river, are full of igneous masses. Precipitous crags of massive greenstones overhang the town, and range through the country along the line of the Caernarvon road. Again the high ridge of Moel-y-gest on the south side of the marshy valley of Penmorfa is wholly composed of greenstone, which alters and bakes the rocks below, which are in immediate contact with it, forming a hard porcelain rock of the slate and shale, and developing in it imperfect crystals which give it a spotted appearance. It is hard to say whether some of the beds occurring in these rocks contain more of volcanic or of sedimentary matter; and farther east as we follow up the valley, the beds become so highly altered and felspathic in character as to obliterate the fossils. The Tremadoc slates were believed to be a very local formation, but when visiting St. David's, I was enabled to recognise their occurrence in that district. Star-fish have been found in them by Mr. Lightbody.

We learn from Professor Ramsay's important, and exhaustive work on the Geology of North Wales,* that certain masses of the igneous rocks, which traverse the Silurian strata west of Snowdon, date from the close of the Lingula Flags and Tremadoc periods. Rhobell-y-fawr, to the north of Dolgelly, is a mass of greenstone, seven miles in length by three in breadth, and it must once have crossed the valley of the Mawddach to Craig-y-Dinas, and Moel-gron, two outliers of the same rocks. This igneous mass was erupted through the Lingula Flags.

Between Barmouth and Rhaiadr Mawddach the Lingula Flags are penetrated by more than one hundred and fifty greenstone dikes. Igneous rocks of the same date run from Penmaen to Arenig; they consist of different kinds of felspar rocks with ashy beds and a kind of porphyry, and again between Ffes-

* "Memoirs of the Geological Survey of Great Britain." Vol. 3, by Ramsay & Salter. Longmans.

tiniog and the sea, the Lingula Flags are interstratified with felspathic grits. Those who consult the earlier memoirs by Prof. Sedgwick, will find that he has described endless alternations of volcanic rocks with these strata.

FOSSILS OF THE LINGULA FLAGS AND TREMADOC BEDS.

In the Lingula Flags, fossil Mollusca are found, and several genera of Brachiopoda have been described as occurring.

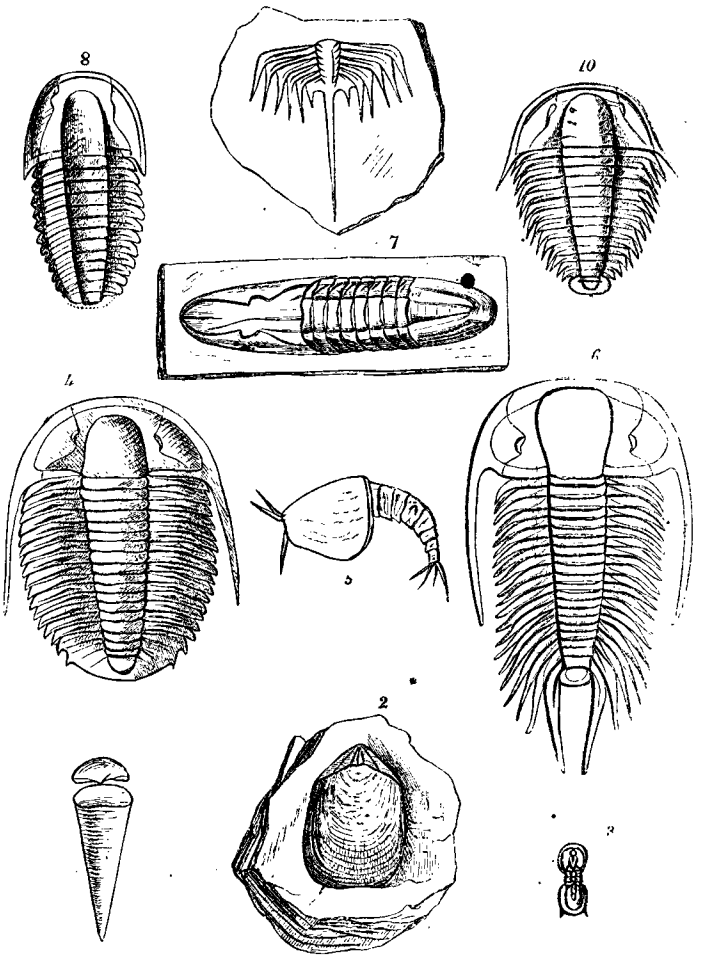
The Brachiopoda are bivalve shell-fish, which were very abundant in the ancient seas, and of which the existing Lingula and Terebratula are examples. The Lingulæ of the Lingula Flags differ little, save in size, from the shells of the same genus found in Torres Straits and other localities in the South Seas. According to Dr. S. P. Woodward,* Lingulæ existed in the British seas up to the time of the Coralline Crag. The Obolella of the Black Shales of the Malverns, first discovered by Miss Margaret Lowe, appears to be a form intermediate between Lingula and the Obolus of Russia, &c.

Several genera of Trilobites have been found, and Mr. Salter informed me that the Primordial, or Upper Cambrian, Trilobites have a peculiar facies of their own, dependent on the multiplication of their thoracic segments, and the diminution of their caudal shield. The Hymenocaris (or membrane shrimp) was a phyllopodus (leaf-footed) crustacean, supposed to be allied to the recent nebalia. The six-pronged tail of this animal occurs in the Lingula Flags.

With these we find Cystideans (so-called from their bladder-like form), animals allied to the sea-urchin or Echinus, and a very simple form of Sponge. In the Tremadoc beds are found a few Cephalopoda of the genera Orthoceras, and Cyrtoceras, animals allied to the Nautilus, and Cuttle-fish; and a Pteropod (Theca) with a conical shell, like the existing Creseis of the Mediterranean. The Cephalopoda are the highest forms of Mollusca, and have been termed the "Scavengers of the Silurian Seas." The Pteropoda (wing-footed) are on the other hand lowly

* See Dr. S. P. Woodward's Treatise on Recent and Fossil Shells.

PLATE I.



1. Theca operculata.
2. Lingulella Davisii.
3. Agnostus princeps. Salter.
4. Angelina Sedgwickii.
5. Hymenocaris vermicauda.
6. Paradoxides Davidis. Salter.
7. Asaphus Homfreyi.
8. Conocoryphe verisimilis.
9. Acidaspis.
10. Olenus micrurus. Salter.

[*Page* 76.

organised univalve Molluscs; they mostly have thin glassy shells, and swim with a pair of wings like fins, to which the name refers, and which extend from the sides of the head. In structure they are, says Dr. S. P. Woodward, "most nearly related to the Marine univalves, but much inferior to them."

A Bellerophon is found in the Tremadoc beds. This shell is believed to be allied to the modern Carinaria or glass-shell, which is a marine gasteropod, found in abundance in the Mediterranean, and Indian Ocean. The Gasteropoda comprise the univalve shells.

No spiral Univalves are known in these old deposits. The Protozoans (first or lowest animals) are represented by the sponges of the Lingula Flags.

CHAPTER IV.

LOWER SILURIAN ROCKS.

Llandeilo Rocks—Cader Idris—Glacier of Llyn-y-Gader—Ramsay on Glacial Lakes—Plants of Cader Idris—Lake of Tal-y-llyn—Dolgelly—Cymmer Abbey—The Arans—Volcanic Phenomena of Auvergne compared with those of N. Wales—The Arenigs—Llandeilo Strata of Snowdonia—Penmanmawr—The Berwyns—The Breidden Hills—The Stiper Stones, and Fossils of—Upper Llandeilos of Builth—Builth Castle, and Antiquities of—Llan Avan—Llanwrytyd Wells—Llynderw—Llangadock—Carn-goch—Llandeilo—Roderick the Great—Dynevor—Merlin—Caermarthen—Pencader—Cydwelli and the wife of Maurice de Londres—Precelly Hills—Musclewick Bay—Caradoc or Bala Rocks—Snowdon—Different Periods of Volcanic Activity in N. Wales—Dinas Mowddy—Bala Limestone—Valley of Hirnant—Bala, Town and Lake of—Vendace of Loch Maben—Habitats of the Coregoni, &c.—Caradoc Rocks of Caernarvonshire—Dolwyddelan—Capel Curig—View from Snowdon—William Williams—Plants of Snowdonia—Rocks of Lleyn—Criccieth Castle—Copper Mines of the Parys Mountain — Conway, Castle and Antiquities of — Diaganwy Castle—Caradoc Rocks of the Berwyns—Corwen and Owen Glyndwr—Castle of Powys—Fault of the Valley of Stretton—Onny, Section and Fossils of—The Wrekin—Horn of the Bannog Ox—Beavers in the Teifi—Llandewi Brevi, Miracles at—Strata Florida Abbey—Organic Remains of the Lower Silurians.

		Typical Fossils.
3. Caradoc or Bala Rocks.	*Trilobites.*	Asaphus Powisii, Calymene. Trinucleus. Cybele verucosa, Homalonotus bisulcatus. Illænus, several species.
	Shells.	Bellerophon bilobatus. Orthoceratites.
	Brachiopods :—	Orthis actonia and O. vespertilio. Strophomena grandis. Bivalve shells of the genera Palæarca, Modiolopsis, &c.
	Univalves :—	Cyclonena, Holopea, Raphistoma.
	Cystidiæ :—	Sphæronites, Echinosphærites, Hemicosmites.
	Starfish.	Palæaster.

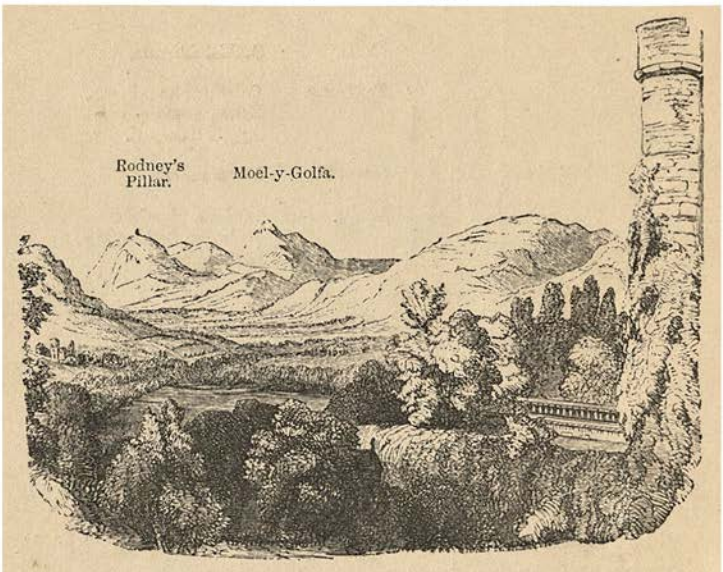
			Typical Fossils.
2. Upper Llandeilo.	Lower Bala of Sedgwick.	*Trilobites*,	Asaphus tyrannus, Ogygia Buchii, Ogygia Corndensis, Agnostus M'Coyii, Trinucleus fimbriatus, T. Lloydii, &c.
		Graptolites.	
		Shells.	Orthis, Lingula, &c.
1. Lower Llandeilo.	Arenig or Skiddaw rocks of Sedgwick.	*Trilobites.*	Calymene parvifrons, Eglina grandis, Ogygia Selwynii.
		Graptolites.	Many genera.
		Shells.	Obolella plumbea, Redonia, Bellerophon, Orthoceras, Maclurea.

Under the term Llandeilo rocks are included two great formations, each characterised by a series of black shales and slates interbedded with igneous masses. These igneous rocks are far thicker in the lower than in the upper group, which is a formation consisting of soft black and brownish slates, with which the igneous rocks are only here and there interbedded, while the lower group is chiefly composed of great igneous masses, spread out and intercalated with the slates.

The Llandeilo group of rocks was named by Sir R. Murchison from the town of Llandeilo, in Caermarthenshire, where many of its characteristic trilobites were collected. It appears that the fossils of the Lower Llandeilo rocks are distinct from those of the upper series. Professor Sedgwick first described beds of this age as being largely developed in the Arenig Vawr and Aran Mowddwy, in Merionethshire.

In this county, the Tremadoc, and underlying Lingula strata, are overlaid by vast accumulations of volcanic ashes and flows of the ancient lava, which circle round the Cambrian, Lingula, and Tremadoc rocks, and are interstratified with black slates, which by their position and fossils indicate that these slates belong to the Lower Llandeilo period of geologists. These volcanic rocks, and interbedded slates, form accumula-

tions many thousands of feet thick, and have been disturbed, and uplifted into mountains, and curved into great undulations; yet, notwithstanding all this, the geologist who studies these strata, and their interbedded volcanic rocks, in the heights of Cader Idris, the Arans, the Arenigs, the Manods, and the



VIEW OF THE BREIDDEN HILLS NEAR WELSH POOL, FROM POWIS CASTLE.
(From a Drawing by Lady Murchison.)

Moelwyns, learns the great geological fact that, whatever may have been the intensity of volcanic action during the period of the deposition of the Llandeilo slates, and however evident the fact that volcanoes were then active in what is now Merionethshire, the igneous rocks at present associated with the Llandeilo strata were not the ultimate cause of the great disturbance of that country; for those igneous rocks have themselves been disturbed, and have undergone precisely the same dislocations and movements as the Llandeilo strata with

CADER IDRIS. [*Page* 81.

which they are interbedded. The same history applies to the Cambrian strata. Another fact we learn from the study of the physical geology of North Wales is that the mountainous features of the country are owing to *denudation* as well as to *igneous action*, and are due to the unequal hardness of the rocks which form the ridges and summits of the mountains, and not to volcanic upheaval of Llandeilo date. Denudation, both submarine, and subaërial, denudation by sea currents, by glacial action, by rain and running waters, and by the action of the atmosphere, aided by faults and dislocations of the rock masses, has combined with earthquake movements to form the noble mountains of North Wales. It cannot be too often impressed upon the geologist, when exploring this country, that the volcanic rock masses, together with the Llandeilo slates interstratified with them, on Cader Idris, the Arans, the Arenigs, and other mountains, are of more ancient date than the volcanic series of rocks interbedded with the Bala or Caradoc strata of the great Snowdonian group of mountains.

Dolgelly, "the dale of hazel groves," is the best locality for the naturalist who would examine the structure of Cader Idris, with its basaltic columns, remains of old glaciers, beautiful wild flowers, and exquisite scenery. When travelling in this district, we are struck with the symmetrical columns of felspar porphyry used for gate-posts, and especially at the turnpike on entering Dolgelly. These columns are quarried on Cader Idris. The geologist will observe also that the felspar porphyries which set in around Dolgelly are of a different mineralogical character to the greenstone dykes in the Cambrian rocks and Lingula Flags. They are not met with among those older strata, and indicate the position of the overlying Llandeilo strata in the Cader Idris country.

The geology of this district is very intricate and difficult. It must here suffice to say that the Lingula Flags, and Tremadoc beds (in which the iron beds occur), traversed by greenstones, may be seen on both sides of the estuary, while the overlying strata, or Lower Llandeilo beds, are the blue

slates which, interstratified with the volcanic masses of felspathic porphyries, ashes, and greenstones, form the mountain mass of Cader Idris, and lie between Dolgelly (passing by Llyn-y-Gader and Lyn-y-Cae) and Tal-y-llyn. These blue slates are regularly interleaved with pumice and ash beds. On Mynydd Mawr, on the north side of Cader Idris, are immense masses of porphyry of the columnar structure already alluded to. I possess a fragment, polished like marble, and marked with cross striæ, which, when travelling through this country with Sir Charles Lyell, I obtained from the old glacier bed which once filled the hollow between Mynydd Gader, and Cader Idris. The rocks of Cyfrwy also consist of columnar porphyry, while south of Cyfrwy and Llyn-y-Gader are the Llandeilo slates, traversed and altered by a dyke of greenstone which runs up to the summit of Cader Idris.

The Llyn-y-Gader lake, at the base of the Cader, is a deep basin, probably hollowed out, as Professor Ramsay supposes, by the masses of slowly moving snow and ice, which for long ages passed down from the cliffs and mountain tops which rise so boldly above the tarn. A similar history attaches to Llyn-y-Cae. Here the erosive action of the glacier has carved out a hollow in Llandeilo slates, greenstone dykes, and felspathic porphyry, without paying much deference to the hardness of the igneous rocks. Both of these mountain tarns are said to nourish the Torgoch, or Welsh Char, in their waters.

And here I may remark that, since the publication of Prof. Ramsay's paper on the "Glacial Origin of Lakes," in 1862 (Quart. Journ. Geol. Soc., Aug. 1862), I have paid much attention to the old glaciers of North and South Wales, and, in company with my friend Sir Wm. Guise, have studied the glacial phenomena of some of the Swiss and Italian lakes, as well as those of the great glaciers of the Alps, and of some of the extinct glaciers of North Italy. I have also twice been among the lakes of Sutherland and Ross-shire, and the more I have travelled and observed in glaciated regions, the more firmly convinced I am of the truthfulness of Prof. Ramsay's

conclusions, with respect to the origin of most of the lakes in every district which has been swept over by glaciers. There is assuredly an intimate connexion between tarns, lochs, lakes, and glaciers in all the mountain districts of Switzerland, Wales, and the Highlands of Scotland, and, from the physical phenomena connected therewith, there can be no doubt that the great lakes of Maggiore, and Como, were once covered by a vast glacier, as were also the tarns of Llyn-y-Cae, and Llyn-y-Gader, by a comparatively minute glacier, "magna componere parvis." They all have been, I believe, swept over by land ice, and owe their origin to glacial action, although they may not have been actually scooped into hollows by *glaciers*. In examining the history of many of the lochs, and tarns, in the west of Scotland, I have found that, as a rule, few of them lie in lines of fault or fracture; fewer still, in synclinal basins; and that everywhere around them, as, for instance, near Laxford, and Loch Assynt, in Sutherlandshire, are proofs of the former existence of ice masses grinding downwards in direct contact with the rocks.

So also in Wales, many of the tarns lie in rock basins directly in the line of an old glacier; and in more than one example, as seen in the two tarns on the Vans of Caermarthen, the last of the glaciers which lingered among the mountains, the last relics, as it were, of retiring ice, have cut a small rock basin in Old Red Sandstone, and have deposited on the edges of the lochs moraine matter, carried only a few hundred yards from the summit of the surrounding hills.

All around Dolgelly, bosses of greenstone are protruded through the Lingula Flags; but between Mynydd Moel, and Mynydd Gader, is a good typical section of the country from Cader Idris to Arenig, and of the interstratification of the Llandeilo slates, and their igneous rock masses. The botanist will find some good plants on Cader Idris; amongst them, Gnaphalium supinum, the rose root (Rhodiola rosea), a mountain Sedum, with the mountain Bearberry (Arbutus alpina), and the Alpine Meadow Rue (Thalictrum minus), also Myosotis alpestris, Veronica alpina, Linaria alpina, and

Silene acaulis, which was the highest plant found by Saussure on the Alps, while Whymper met with it on Mont Blanc at a height of 11,388 feet above the sea.

The Upper Llandeilo, or Lower Bala strata are hollowed out into the Lake Tal-y-llyn, which beautiful sheet of water has been described as the heaven of the disciples of Isaak Walton. The contrast between the scenery on the north and south of Cader Idris is owing to the absence of igneous rocks among the black shales, of which the smooth rounded hills towards the south are composed.

There are but few points of archæological interest around Dolgelly. There is a note in Gibson's "Camden," of Roman coins being found in a well called "Ffynon Vair." The Parliament House, near the Ship Hotel, is said to have held the parliament of Owen Glendwr in 1404; and about two miles from Dolgelly are the ruins of Cymmer Abbey, which was founded about 1198, or ten years after the journey of Giraldus Cambrensis.

The Aran range, with its mountain peaks, Aran Mowddy, and Aran Benllyn, resembles the rocks of Cader Idris lithologically, and has also much the same geological history, while the rocks of the Arenigs belong to the same horizon, and are constituted of interstratified igneous and Llandeilo rocks. The principal difference in the structure of these mountains is the thickening and thinning out of certain of the igneous series of rocks in different localities on different geological horizons. Thus, whereas on Cader Idris there is a thick bed of igneous rock in a certain position with regard to the Llandeilo slates, on the Arenigs this mass will have nearly thinned out, while on their flanks other thick-bedded igneous masses will appear in a different geological position to that which interbedded lavas and ash beds occupy on Cader Idris or on the Arans. This is precisely similar to examples observed by Sir Wm. Guise and myself in the volcanic districts of Central France. Near Clermont Ferrand, on the hills of Gergovia, above Romagat, at the Puy Girot, the Puy de Dallet, and in many other localities, we find, interstratified with the products of volcanic eruptions, the freshwater lime-

stone known as the "indusial limestone," on account of its being filled with the cases of the caddis-worms that frequented the Miocene lakes of ancient France.

The deposits of the great Limagne lake contain, not only the remains of the May flies that flew over its waters, together with the freshwater shells agglutinated round the cases of their larvæ, but also the remains of the vertebrated animals which lived on its shores. Relics of these we saw in the museums of Paris and Clermont Ferrand; and amongst them were the remains of Deinotheria, Rhinoceri, Palæotheria, Tapir, Palæocherus, Hyænodon, crocodiles, tortoises, birds, serpents, fish, and batrachians. But, to those who have studied the old rocks of Wales, the most interesting fact is the unquestionable evidence, here afforded, that volcanic eruptions of basaltic lava and scoriæ were poured forth into the freshwater lake of the Limagne long before its sedimentary matter of limestones and marls had ceased to be deposited. In the hills of Gergovia we have marls and limestones interstratified with volcanic ashes, and above and below are caddis-worms; in the same manner, we may sometimes see, in Wales, trilobites covered with an overflow of greenstone. There are also true volcanic dykes in Gergovia, which penetrate the limestone strata, proving that volcanic eruptions were intruded through the bed of the lake itself. In the Puy de Dallet, near Pont du Château, we found casts of freshwater shells, such as Planorbis and Lymnea, imbedded in a regular volcanic ash, which had probably been ejected as pumice or peperino from a volcano into the air, and, falling into the lake, gradually sank to the bottom, where the shells and the caddis-worms were living and crawling beneath the waters.

The hill of the Puy de Dallet is capped by an outlier of basalt, in the same way that Cader Idris is capped by basaltic felstone porphyry, the basalt of the Puy de Dallet being, however, a representative of volcanic eruptions in the days of the Miocene tertiaries, when hundreds of great extinct quadrupeds frequented the land, whilst the basaltic columns of Cader Idris were poured forth in the days of the Llandeilo crustacea, and,

as far at least as the geologist has any proofs, long before any mammalia had been called into being.

Bala is the best place for head-quarters for a visit to the Arenig mountains. They rise to a height of 2800 feet, and their rocks consist of igneous porphyries, similar to those of Moelwyn and the Aran group, and they likewise exhibit the phenomena first alluded to, of the thickening out of masses of volcanic ashes on different horizons. It appears that there is no doubt about the age of the slates on the flanks of the Arenigs, as at Taiheiron, a mile S.W. of Arenig Bach, and in other localities, they furnish trilobites, such as Ogygia and Calymene, already given in the list of typical fossils, together with graptolites, proving that they belong to the Lower Llandeilo group of Murchison, or the Arenig and Skiddaw group of Sedgwick, who was the first to define this group of rocks, and to discover its fossils. There are several slate quarries on the Manod mountains, and in the neighbourhood of Ffestiniog, in the Upper Llandeilo beds which overlie all the volcanic ashes and felspathic porphyries that range from Moelwyn to Arenig, and the Arans, while in the Arenigs the lowest Llandeilo beds are overlaid by mountain masses of felstone porphyries, and other igneous rocks, which will give the physical geologist some idea of the vast outpouring of volcanic matter which must have been erupted during the Llandeilo period

In the Snowdon district the Llandeilo strata are thrown down by great faults; but in certain localities, as between Marchlyn Mawr and Y-Garn, they appear interstratified with felspathic lavas, and traversed by greenstone dykes. Llandeilo fossils have been found east of Y-Trifan, on the N.N.W. of Snowdon, in beds overlying the Lingula Flags; and the black slaty shales on the banks of the Seiont, opposite Caernarvon, have yielded some Llandeilo graptolites. The physical geologist, who observes the position of the Lower Cambrian rocks and the Lingula Flags on Moel-y-Trifan and the surrounding district, will perceive the difficulty there is in assigning to these rocks the horizon of the Llandeilo strata. Mr. Salter

who found graptolites on the hill-sides after three days' search for a single specimen, informed me that *Bellerophon perturbatus* is one of the commonest fossils in the Upper Llandeilo Flags, and occurs very rarely in the Caradoc rocks above; and as this fossil has been found in black slaty rocks below Penrhyn Park, Bangor, these strata are believed to belong to the Upper Llandeilo Flags.

Penmaenmawr, near Conway, is an igneous rock which has been erupted through Llandeilo strata. It is the advanced guard, towards the sea, of the chain of hills which stretch eastward to Capel Curig. On the summit of Penmaenmawr, the antiquary finds Braich-y-dinas, a British stronghold, where the remains of the Welsh army were posted during the negociations between Llewellyn and Edward I.

The botanist cannot fail to mark the contrast in the flora of Penmaenmawr as compared with that of the Mountain limestone of the neighbouring rocks of Llandudno. The vegetation is as different as the mineralogical character of the formations. The ferns Hymenophyllum and Allosorus grow on Penmaenmawr, but they are unknown at Llandudno, while many a plant of the Great Ormes Head finds no footing on this noble hill on the other side of the narrow straits.

The Berwyn mountains constitute the division between the counties of Merioneth, and Montgomery for more than thirty miles; their highest peaks, Cader Berwyn and Cader Tronven, rising to the height of 2710, and 2585 feet respectively. In these hills the Cambrian rocks, and the Lingula Flags, are not elevated to the surface; but in the lower rocks there are masses of felstones, and volcanic ashes, which are supposed to be the equivalents and representatives of the igneous rocks we find interstratified with the Lower Llandeilo strata of Wales. I am, however, inclined to believe that the Llandeilo strata of the Berwyns are altogether higher in the series than the Merionethshire strata, and that they belong to the Upper Llandeilo series, as developed near Builth, Llandeilo, and other localities. They may be the equivalents of the upper roofing Llandeilo slates, which underlie the Caradoc strata in the

neighbourhood of Ffestiniog. Near Llangynnog are quarries and lead mines, which may be well seen by crossing the country from Bala, a distance of about thirteen miles. The village of Llangynnog is romantically situated at the confluence of the Tanat and the Eraith; northwards Craig Rhiwarth towers

LLANDEILO AND CARADOC ROCKS ON THE EAST FLANK OF THE BERWYNS.

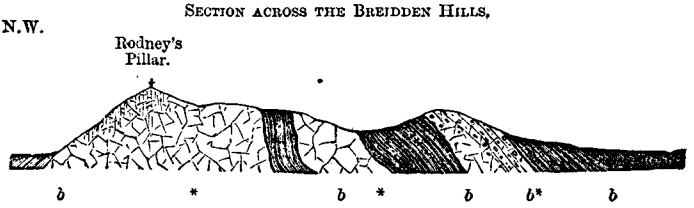
b, Black Slates. *b'*, Llandeilo Limestones and Schists. *c*, Caradoc Sandstones.

above it; other lofty ridges rising towards the south. The highest pass of the Berwyns is called Milltyr Gerrig (the mile of stone); and the country round this district, between Pennant and Llandrillo, should be examined; also the pass leading down to Llanrhaiadr-yn-Mochnant. The Landeilo strata are exposed on the eastern slope of the hills, and near Llanrhaiadr-yn-Mochnant they become calcareous, forming a limestone crag, named Craig-y-Glyn. The characteristic fossils of the Upper Llandeilos, Asaphus tyrannus, and Trinucleus favus, are found here, with an Orthis. Pistyll Rhaiadr, some four miles from Llanrhaiadr, is one of the finest waterfalls in North Wales; it is upwards of 240 feet in height, and rises in a dark wild glen with blue slaty Llandeilo rocks ranging on either side of the gorge. The river Rhaiadr runs upon a line of fault, the beds on the western side being elevated above those on the eastern. The coomb under Cader Berwyn, on which the river takes its rise from the lake Llyn Caws, shows glacial evidences.

The Parsley Fern (Allosorus crispus), grows very luxuriantly near the cataract; and many good plants flourish about Craig-y-Glyn.

The Breidden hills, near Welsh Pool, rise to the height of 1200 feet, the most precipitous peak being the picturesque Moel-y-golfa, 1143 feet. The whole range marks a line of

eruption ranging from S.W. to N.E. The hills are a mass of igneous rocks, carrying up with them dark slaty rocks of the Llandeilo period, and throwing off pebble beds and the Upper Silurians of the Long Mountain. Fossils are found near the trap rocks at Welsh Pool. At Bauseley Hill shales and trappean



b, Lower Silurian Slaty Rocks. *b**, Cotemporaneous Volcanic Breccia.
*, Eruptive Rocks.

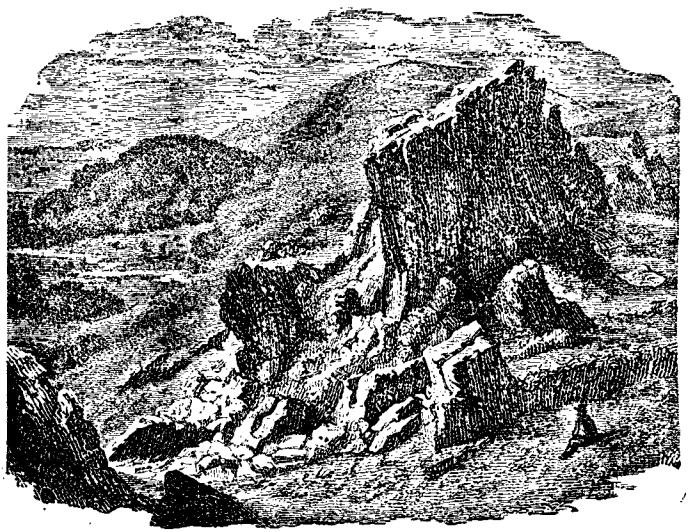
ash beds are thrown off from the trap rocks, and contain fossils. The Black Rock is remarkable as a botanical station for several rare plants. This hill is the only British habitat for Potentilla rupestris, and on it also flourishes Lychnis viscaria, with Geranium sanguineum, Veronica spicata, V. hybrida, and Saxifraga hypnoides, most of which grow on Stanner rocks (volcanic rock also) near Kington in Herefordshire.

The large Camp on the hill lays claim to be that on which the British chieftain, Caradoc (or Caractacus), made his last stand, although some antiquarians still contend for the Caer Caradoc of the forest of Clun having been the scene of this struggle.

STIPER STONES OF SHROPSHIRE.

The Stiper Stones of Shropshire were first described by Sir Roderick Murchison in that splendid work, "The Silurian System," a work which every geologist will reverence who has examined the country to which it refers, and bears in mind how little was known of the rocks, or fossils, of that rugged land when, before the days of Geological Surveyors, the gallant Soldier and his devoted Wife went forth side by side, one with

his hammer, and the other with her pencil, and unravelled their ancient history. And in order to appreciate the work done, let the geologist try his hand without survey maps, and survey books, and the aids we possess, now the days are over when men worked out such histories for the love of the records



THE EASTERN FACE OF THE STIPER STONES.

of the rocks alone. The Stiper Stones form a very remarkable ridge of quartzose rocks, extending for ten miles, from Pontesbury, near Shrewsbury, on the N.N.E., to Snead, near Bishops Castle, on the S.S.W., and rising to a height of 1500 feet above the sea. They are now ascertained from their fossils to belong to the Lower Llandeilo period. Their position with regard to the Cambrians of the Longmynds may be best understood by consulting the section. Trap bosses and greenstone occur on both sides of the ridge, and the beds are without doubt much metamorphosed; they contain, nevertheless, Lingula plumbea. There are worm tracks

and burrows (Arenicolites linearis) in the rocks of the Stiper Stones. They occur as long vertical tubes, with trumpet-shaped openings, in the quartz rock. These worm-tubes are very similar to those observed by Dr. Macculloch on Queenaig in Assynt, and which are described by him in the "Transactions of the Geological Society" as early as 1814. There the numbers of these cylindrical tubes strike every observer; and on an expedition two years ago, in company with Captain Price, I ascertained that the quartz rock of Queenaig with its tubes rests unconformably on Cambrian conglomerate. It is very probable that this Queenaig quartz rock, as well as the Assynt limestones, is of Lower Llandeilo age, like the Stiper Stones. Dykes of greenstone were detected by Mr. Gibbs, collector to the Geological Survey, on the eastern side of the Stiper Stones; and on the western side of the ridge the Llandeilo rocks are interstratified with volcanic grits and ashes. These bands may be seen at Cefn-y-Gwynlle. The great Corndon Mountain is an igneous mass, erupted through these strata. The Stiper Stones district is the only one I know where the Lower Llandeilo rocks, containing Lingula plumbea, and Ogygia Selwynii, are seen to pass upwards into the Upper Llandeilo Flagstones of Builth and Llandeilo, with Ogygia Buchii and Asaphus tyrannus. This is the case between Shelve Hill and Meadow Town; but the upper strata are not conformable to the lower, and there appears to be a break between the two formations. Sir Charles Lyell will remember my pointing out this unconformability to him in the year 1855, when we visited this district from Linley Hall in company with the Rev. T. T. Lewis of Aymestry, and when the Stiper Stones were believed to be the representatives of the Lingula Flags.

I heartily recommend the student who wishes to master thoroughly the intricate geology of this district, to spend a considerable time at Church Stretton, Bishops Castle, and Montgomery. At Nils Hill, near Pontesbury, the Stiper Stones formation may be seen in two hollows, in the more northern of which ripple-marks occur, and worm-tubes, these beds are quarried for road stone, and are not much meta-

morphosed. Granham again to the north of Vesson's Coppice, near Pontesbury, exhibits beds which are crystallised and apparently altered by heat. Eskridge near Lord's Hill, should also be visited. In the Shelve district, between Montgomery and Bishop's Castle, on the western flank of the Stiper Stones,

LOWER SILURIAN TRACT WEST OF THE STIPER STONES (SHELVE, &C.), THE CORNDON MOUNTAIN IN THE DISTANCE TOWARDS THE NORTH.

Lower Silurian Rocks, interstratified with contemporaneous ashes and lavas, and traversed by Eruptive Rocks.

the Llandeilo formation contains, together with characteristic fossils, many interstratified bands of volcanic materials. Lead ore is obtained from these rocks, around the village of Shelve, and here too, the igneous mass of the Corndon mountain is erupted through the strata. Cefn-y-Gwynlle, White Grit Mine, and Lord's Hill are good localities for fossils. At the Bog Mine, the mineral veins traverse a vast number of the thin-bedded felspathic grits, or ashes, interstratified with the schists and flags charged with trilobites and graptolites. Many fossils may also be found at Ritton Castle, and at Disgwylfa, near Snead.

The geologist should visit the Whiterry quarries and their interbedded traps in Marrington Dingle. The lower Llandeilo

beds are succeeded by a series of flagstones partly calcareous, dark grey and light blue in colour; they constitute the upper Llandeilos and contain Asaphus tyrannus, and Ogygia Buchii.

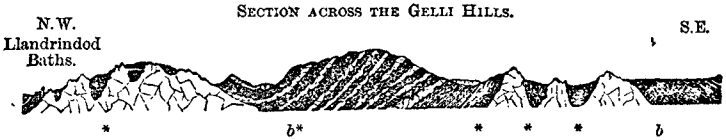
UPPER LLANDEILO.

In South Wales we have the Llandeilo rocks appearing in the district extending from Llandegley in Radnorshire, to Llandrindod, and Builth on the Wye. This elevation of these rocks by volcanic action to the surface, is ten miles in length by about five in breadth, and reminds us of the district of Shelve and Corndon. The strata belong to the upper Llandeilo Flags, and contain abundance of the typical trilobite Ogygia Buchii and O. corndensis, with Asaphus tyrannus (rare), and Orthis calligramma. Igneous rocks are erupted in the Carneddau hills, and Llandrindod hills, and volcanic traps and ashes are interbedded with marine strata in the Llandegley rocks, and Gelli and Gilwern hills. The bedded rocks are best seen in the sections of the Gelli hills, and flagstones full of trilobites, Ogygia Buchii, and Ogygia corndensis, are found at upper Gilwern. The Carneddau hills carry up fragmentary portions of the Llandeilo Flags to considerable heights on their sides. In this district the upper beds are black shales and white sandstones which rest conformably on flaggy strata with interbedded traps and volcanic grit. The graptolites, Didymograpsus Murchisoni, and Diplograpsus pristis are found in the black shales, and also occur in the Upper Llandeilo slates of Abereiddy Bay. Asaphus tyrannus appears to be somewhat rare in the Builth country, and is generally found in the lower beds.

There is a celebrated salmon catch about a mile above the bridge at Builth,* known as "The Rocks," where the igneous masses may be seen cutting through the Llandeilo beds. The fisherman wading will soon find them out, for the felspathic trap is rough and good walking, and the slate beds of the Llandeilo

* Several geologists live around Builth, and the stranger will ever meet with kindly attention, and good local information, from Mr. Jones, gardener at Pencerrig, or Mr. Griffiths, of Builth.

rocks are as slippery as glass. Close to Pencerrig, near Builth, is an instructive section, on a small scale, where the upper Llandeilo rocks may be seen interbedded with volcanic masses.



b, Llandeilo Flags. *b**, Llandeilo Flags with interpolated cotemporaneous Felspathic ashes, &c. * Eruptive Rocks.

The mineral waters of Builth are the result of the contact of a *trap dyke,* traversing black slates of the Llandeilo strata, which at the point of contact are highly charged with crystals of iron pyrites. Decomposition of the pyrites by the percolation of water is continually going on; other sulphates, chlorides, and sulphurets furnish their quantum, the result being about as distasteful a beverage as can well be imagined.

The botany around Builth is good. The Moonwort (Botrychium lunaria) grows in great profusion on a slope opposite the house of Pencerrig; while the Parsley Fern (Allosorus crispus) flourishes in abundance on the interstratified Llandeilo and volcanic rocks of Gilwern, as if it had been transported from the distant Berwyns, or the far-off hills of Arenig, to the isolated and uptilted range that runs from Builth to Llandegley. The moonwort has been found as far south as the Straits of Magellan.

Camden, quoting Ptolemy as his authority, recognises in Builth, the ancient Bulleum Silurum of the Romans.* Antiquaries tell us that Builth Castle was built before the Conquest, and, at the time of the Norman invasion, was held by Cadwgan Glodrydd, a Breconshire chieftain, who was reduced to subjection in the days of William Rufus, by Bernard Newmarch. It was held by Roger Mortimer in 1260,

* See Gibson's "Camden," p. 590.

and was taken by the Welsh under Llewellyn, the last native Prince of Wales. Leland informs us that Llewellyn was killed near Builth, the narrow dingle called Cwm Llewellyn is said to be the place where he was taken. His head was cut off and sent to Edward I., then at Rhuddlan Castle in Flintshire, and he had it sent to London, there to be placed upon the Tower. The castle was standing in Henry VIII.'s time, as Leland saw it, and describes it as "a fair castel of the kinges."

Near Builth, is Llan Avan, of which Sir R. Colt Hoare tells us that Giraldus Cambrensis thinks "it proper to mention," that in the reign of Henry I., the Lord of the castle of Radnor entered the church of Llan Avan, and without sufficient caution and reverence, passed the night there with his hounds. "Arising early in the morning, according to the custom of hunters, he found his hounds mad, and himself struck blind."

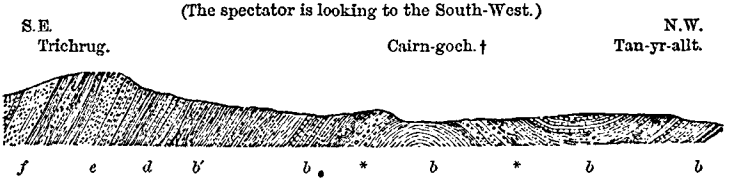
The rocks of Llanwrtyd-Wells, in Breconshire, are black schists and flags of Llandeilo age, traversed and altered by volcanic rocks. These wells owe their origin to phenomena similar to those we have described as occurring in the springs of Builth. The well is called "Ffynnon drewllyd," or the Stinking Well. Many years ago, I geologised on several occasions over this difficult district near Llynderw, the residence of an old friend, Captain Roberts, a geologist of the old greywacke school, who possessed a collection of fossils found in some lead mines worked near his house. Among them were graptolites, and trilobites, distorted by slaty cleavage. In walking from Llanwrtyd, by Abergwessin, the Drygan Mountain, and Claerwen, to Rhayadr, we pass through some wild scenery, and interesting geology. The excavations of the little river Gwessin, at the "Wolves' Leap," and other places, are especially worthy of attention, as showing the action of mountain streams upon hard rocks. There is also some good evidence of glacial phenomena around the Drygan, and the little glacial lake which lies at its base. The Kite, now become such a rare bird, may still be found among the rocks of the Drygan.

In visiting this country, the geologist may enjoy a good day

over the Upper Llandeilo strata by going to Llandovery, and thence by train to the station at Llangadock, in Caermarthenshire, and tracing the section from Tan-yr-allt with undulations of Llandeilo schists, flags, and interstratified traps, to Trichrug, where Upper Silurian rocks, and Old Red Sandstone, succeed.

SECTION NEAR LLANGADOCK. FROM THE LOWER SILURIAN TO THE OLD RED SANDSTONE.

(The spectator is looking to the South-West.)



b, Undulations of Llandeilo Schists, Flags, and Limestone, with interstratified Trap *. *b'*, Llandeilo Sandstones, &c. *d*, *e*, Upper Silurian. *f*, Old Red Sandstone.

This section is described in "Siluria." It exhibits an arched arrangement of the stratified deposits and interlaced traps. Fossils are found at Coed Sion, and the flags thrown up from Blaen-dyffryn-garn, on the Sowdde river, afford fossils, occurring in the interstratified trap beds. Amongst them is the typical Ogygia Buchii, Pen-y-goylan is another good locality for this trilobite.

Sir Roderick Murchison was the first geologist, who discovered in 1833, the existence of volcanic rocks in Caermarthenshire. The spot where he first recognised them is known under the name of "Blaen-dyffryn-garn," and is about three miles from the old town of Llangadock upon the river Sowdde.

The geologist should ascend the hill of Blaen-dyffryn-garn and walk to the knoll at the northern extremity where the volcanic rock forms the ridge and throws off the Llandeilo siliceous rock of Carn-goch, and the overlying Llandeilo slates full of fossils on both sides of the ridge. On the northern slope of this hill, a little above the farmhouse, there is a remarkable boulder of red rock stranded against the quartzite, and which is probably derived from the Lower Old Red of the

Trichrug-ridge above. The quarries of Coed Shon a quarter of a mile to the north-east, afford many fossils of the Llandeilo series.

A little to the north of the hill of Blaen-dyffryn-garn was formerly a cromlech which stood in the low grounds. It was destroyed by a peasant; but beneath it were found human bones, and the legend is that this was the last place in Great Britain where human sacrifices were offered.

The British encampment of Carn-goch, on the summit of a detached hill, three miles S.W. of Llangadock, stands on a stratified siliceous rock of Llandeilo age. This quartzose rock has been heaped into massive defensive walls, enclosing what must have been a formidable stronghold in early times. When visiting Llandeilo some summers ago in company with Professor Harkness, we walked over the section from the Carboniferous limestone of Castell Cerrig-Cennen, by the Deserted House, and over Trichrug to this Llandeilo upthrow of Carn-goch. It is a walk which no physical geologist or lover of scenery would be likely to forget.

Llandeilo is situated on the Upper Llandeilo Flags. Near the town are some good sections, and abundant fossils are to be found. When the Pont Ladies section was laid open on the construction of the Llanelly and Llandovery railway, beds full of carbonaceous matter containing corals, and overlaid by beds containing fossils were exposed. This section is about a mile on the Llandybie road; and exhibits a dome-formed arrangement of the strata. The typical trilobite of the Upper Llandeilos, Ogygia Buchii, is to be obtained in quarries close to the town as well as in Dynevor Park.

It is necessary to mention that the Government Survey detected a hiatus of Caradoc rocks, on the left bank of the Towy, although on the opposite or right bank of the river they are exposed in proper order overlying the Llandeilo Flags. This is the case all the way from Caermarthen, by Llandeilo, and on to Builth, where the Middle Silurian Pentamerus beds may be seen in a quarry close to Pencerrig resting unconformably on Llandeilo Flags, interlaced trap rocks and

siliceous deposits, like those of Carn-goch, without the intervention of the Caradoc rocks.

The lowest strata at Llandeilo are sandy flags with beds of limestones, and the typical fossils are Asaphus tyrannus, A. peltastes, with a small variety of Ogygia Buchii, named O. convexa (Salter). The upper strata are brown flags and black shales full of O. Buchii, and graptolites; they occur at Dynevor Park and at Llandybie road. Magnificent specimens of that fine trilobite Asaphus tyrannus may be obtained in the neighbourhood, and from the information I received from Mr. Williams, and Mr. Samuel of Cerrig-Cennen, it would appear that it is more commonly found in the lower strata than in those upper flags which contain such abundance of the Ogygia Buchii. One specimen, in the possession of Mr. Williams, measured eleven inches in length, and another, presented by the Earl of Cawdor to the British Museum, is still finer.

There is a good deal of historic interest connected with Dynevor. About the middle of the ninth century Rhodr Mawr, or Roderick the Great, Prince of Gwynedd, wished to unite the whole of Wales into one kingdom, and established the seat of government at Dynevor. Subsequently Cambria was erected into a separate kingdom, and Dynevor, on the Llandeilo rocks, was bequeathed to his son Cadell as the future residence of the princes of South Wales. The remains of the castle stand upon a bold headland; and, ruinous and ivy-covered as they now are, they are interesting to the lover of antiquarian lore; for the wars of the Welsh raged around the site of Dynevor for many a year, and one fortress after another rose on the ruins of the last. Giraldus mentions a spring at Dynevor "which like the tide, ebbs and flows twice in twenty-four hours," and it was close to Dynevor that Merlin's Cave was placed by Spenser on the banks of the Towy.

> "And if thou ever happen that same way
> To travel, go and see that dreadful place,
> It is a hideous, hollow, cave-like bay,
> Under a rock that has a little space
> From the swift Tyvi, tumbling down apace
> Amongst the woody hills of Dynevowr."
>
> *Faerie Queen*, 3 cant. 3.

The ruins of Dryslwyn castle occupy a bold hill in the vale a few miles below Llandeilo. The earthworks are extensive, and the castle is said to have been erected about the time of Edward the First by one of the princes of Dynevor. I was informed by Mr. Samuel of Cerrig-Cennen that there is an account in the "Archæologia Cambrensis" of a letter written by the Governor of Cerrig-Cennen Castle to the Governor of Dryslwyn to ask his intercession with Owen Glendwr, who it appears took him prisoner and shut him up at Dryslwyn.

Roman relics have been discovered at Llandyfeisant, and silver coins have been found when a portion of some buildings were exposed.

Caermarthen, the Maridunum of Ptolemy is mentioned by Giraldus Cambrensis as an ancient city standing on the banks of the noble river Tywy, surrounded by wood and pasture; it was strongly enclosed with walls of brick, part of which still remain. The same author says that "Caermarthen signifies the city of Merlin," the renowned magician who lived in the days of King Vortigern according to the traditions handed down by the Norman writers of the courts of Henry II., or Richard I.

The local legend is that at his birth, Merlin was covered with black hair, and gifted with the power of addressing expostulations to his nurse. An old legend also connects the fossils of Pensarn, and Mount Pleasant, with the deeds of the great magician, whose last days were as singular as the earlier portion of his life. He fell in love with an angel sprite, or fair fay, without succeeding however in gaining her affection in return. One summer's day when the birds were singing, and the butterflies flitting, the wizard and the fairy entered a rocky cave, and here by the aid of a spell taught her by Merlin himself, the fairy closed the cavern and entombed the magician and the butterflies. Thus Merlin was "lost to life, and use, and name, and fame," and hence the appearance of the butterflies (or trilobites' tails) in the rocks of Mount Pleasant. A romantic origin for Asaphus tyrannus, and Ogygia Buchii.

Caermarthen itself stands on Caradoc rocks, consisting of

black shale with grit bands. Near the town occur also Llandeilo beds as well as Upper Silurians and Old Red Sandstone beds. Barrandia Murchisoniæ, and Orthis alata, with Orthoceratites, may be found near Caermarthen. At Abergwili two miles north-east of the town, are slaty and trappean beds, and there are slates with graptolites at Bwlch Capel, three miles north-north-west of Caermarthen.

Antiquaries should pay a visit to Pen Cader where the Welsh prince Rhys ap Gruffydd surrendered his sons as hostages to Henry II., who, two years after, because his troops were defeated by the gallant mountaineers, wreaked his vengeance upon the wretched hostages. "He did justice on the sonnes of Rees, and also on the sonnes and daughters of other noble men that were his complices, verie rigorouslie: causing the eies of the yoong striplings to be pecked out of their heads, and their noses to be cut off or slit." Alas for the treaty of Pen Cader, and the honour and justice of a king!

Giraldus, who was living at the time, and gives some account of the transactions connected with this invasion, and the surrender at Pen Cader, tells a curious history of a soldier sent by Henry II. to explore the situation of Dynevor Castle. He was misled by the Dean of Cantref Mawr, who "led him purposely aside by the most difficult and inaccessible paths," and himself "fed upon grass," asserting that in times of need the inhabitants of that country were accustomed to live upon roots and herbs. The soldier returning to the king and relating what had happened, affirmed "that the country was inaccessible, and only affording food to a beastly nation feeding like brutes."

Nine miles distant from Caermarthen lie the fine old castle and town of Kidwelly. They are situated on the banks of the river Gwendraeth which rises on Mynydd-Mawr and flows into the Bay of Caermarthen. The* Castle is said to have been founded by William de Londres, the founder of Ogmore Castle in Glamorganshire, but no Norman work is visible.

* A section of the Coal-measures on which the Castle stands is to be seen supporting its western wall.

It is fairly preserved, its towers and walls still standing, but the present remains are evidently not of later date than the times of Henry III. or Edward I. The gate-house is Perpendicular, of the time of Richard II. or Henry IV., while the chapel dates from the reign of Edward I.

Giraldus Cambrensis records visiting "*Cydwelli*," and tells a story of the wife of Maurice de Londres, who had a forest there, "well stocked with wild animals, and especially deer." On the side of the wood next the sea were extensive sheep pastures. "His wife, for women are often very expert in deceiving men," wished to get rid of the deer, and persuaded De Londres that they attacked the sheep "with unheard-of rage and unusual ferocity;" and having caused wool to be inserted into the bowels of two stags, showed it in proof that they had eaten the sheep.

The Precelly hills in North Pembrokeshire form a range about seven miles in length; the highest and central eminence, Moel-Cwm-Cerwyn, is 1735 feet above the sea. The hills are crossed by the Great Western Roman Road, called the Via Flandrica, as it was erroneously supposed to be the work of the Flemish settlers. They are studded with ice-carried boulders, which were used for cromlechs and tumuli by a pre-historic race of men. As regards their geological formation, we find that they belong to the age of the Upper Llandeilo Flags; there are several hills, outliers from the main range.

The wild neighbourhood of Pencaer, in North Pembrokeshire, is well worth a visit. The French have twice landed an invading force among these rugged headlands; once in 1071, under Martin de Tours, who took up his residence on the scene of his conquest; and again in 1797, when their leader, General Tate, found his quarters in Pembroke gaol. Throughout the wide district between Fishguard and Haverfordwest, between St. David's and the river Neven, the Llandeilo Flags, interlaced by great masses of trap, may be said to be the rocks of the country, and having resisted denudation, through the hard lava-like materials of which they are composed, they have

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produced the undulating and rugged scenery which characterises this part of Pembrokeshire.

On the west coast, between Strumble Head and St. David's Head, the Upper Llandeilo Flags are to be seen in a magnificent section at Abereiddy Bay. The beds are nearly vertical. This locality is given by Sir R. Murchison in his "Silurian System" (1839), as an instance where the lines of bedding and stratification are coincident with those of slaty cleavage. The coincidence occurs only in the south side of the bay and is proved by fossils, large double graptolites, found in the beds, appearing undistorted on the lines of slaty cleavage.

LOWER SILURIAN ROCKS IN ABEREIDDY BAY.

Coincidence of Slaty Cleavage and Bedding.

At St. David's Head, in Whitesand Bay in a great reef, called Trevgyn-nowddyn, the Tremadoc beds are seen to pass upwards into dark slates with some peculiar fossils which are referred by Salter and Hicks to Lower Llandeilo beds. They also occur in force on Ramsay Island. At the northern side of the Bay, the black Llandeilo beds are vertical.

This locality is celebrated for having furnished many specimens of peculiar trilobites and other typical fossils. The large rare trilobite Ogygia peltata is found here in the black schists. The section is nearly opposite to the dangerous outlying rocks known as the "Bishop and his Clerks" "who preach deadly doctrine to their winter audience." It was on these rocks that the "Nimrod" struck a few years ago, and every soul on board perished.

In south Pembrokeshire, near Milford Haven, the physical geology of the Lower Silurians is very intricate. In the rocks of Musclewick the upper Llandeilo beds with their character-

istic fossils are exhibited as hemmed in by faults. They are exposed for half a mile and are overflowed on their southern flank by trap masses, while on their northern flank, they are in contact with Old Red Sandstone. Black shales full of graptolites are exposed at Clarbeston, north of Haverfordwest,

LLANDEILO SCHISTS IN MUSCLEWICK BAY

o, Old Red Sandstone. *b*, Llandeilo Schists. *, Eruptive Rocks.

and there are several roadside sections in the route between Haverfordwest and St. David's. In this district the observer cannot fail to be struck by the large boulders which are here and there deposited on the upturned Llandeilo Flags, and other strata. Some years ago they were far more numerous than at present. They were all derived from the volcanic and trappean hills which rise so abruptly from the plain towards the north. The boulders are often imbedded in masses of angular unrounded Llandeilo schists.

CARADOC OR BALA ROCKS.

The Caradoc Sandstone was so named by Sir R. I. Murchison, after the ancient British encampment of Caer Caradoc, which was once believed to have been the site where Caractacus made his last stand against the legions of the Roman general Ostorius Scapula. For a long time this formation was confounded with the Hollies limestone beds, strata now known as the Upper Llandovery, or May Hill Sandstone group, and which lie at the base of the Upper Silurians, as defined by Professor Sedgwick in 1851.

The activity of the volcanoes that poured forth their lava, scoriæ and ashes, during the period of the deposition of the Llandeilo rocks, ceased for a time, and over the igneous masses and the Upper Llandeilo slates of Merionethshire, were deposited

strata of great thickness, and containing the now well-known fossils of the Caradoc or Bala period. Before, however, the close of the Caradoc period in North Wales, volcanic activity recommenced, and, as happened in Auvergne, in far later geologic epochs, new volcanic vents poured forth their lavas and ashes, which in their turn were overlaid by the sediments of a Caradoc sea, and became interstratified with them.

Snowdon is the remnant of an active volcano of the Caradoc epoch, and it is the repeated interstratification of the Caradoc slates with porphyries, greenstone, and other igneous rocks which causes the jagged and serrated peaks of this noble mountain to stand out in such clear, sharp, outlines. The geologist who ascends to the summit of Cader Idris and looks first north and then south, will understand that, although the smooth rounded hills on the south are rocks of the same age as those of Snowdon, Carnedd Davydd, and other Caradoc mountains seen in the distance, the reason of the difference in their outline is, that the Caradoc strata on the south were deposited beyond the flow of the lava currents, and are therefore entirely free from that interstratification with the igneous masses furnished by the old volcanoes of the Caradoc period, and of which Snowdon and other hills of Snowdonia are the roots and remnants.

Caradoc strata are spread far and wide over the South Wales country south of Cader Idris; these beds are let in by a fault at Tal-y-Llyn on the south east of Cader Idris. The district between Tal-y-Llyn, Towyn and Machynlleth, is particularly barren in fossils, and the rocks appear to resemble, rather the nearly unfossiliferous grits of the Lower Llandovery series, than the fossiliferous Caradoc strata of Bala and other districts.

We must never forget when studying these strata, that there were in North Wales *two* well-marked periods of volcanic action. The more ancient of these periods probably commenced in Cambrian times, and continued, as before said, with periods of intermission, throughout the epoch marked by the deposition of the Lower Llandeilo strata. This earlier period

must have been long anterior to the Snowdonian outburst of igneous rock, for five thousand or six thousand feet of sedimentary beds are intercalated between the volcanic masses of porphyry, grits and ashes, which are interstratified with Caradoc strata and contain Bala fossils.

It would appear that after this period of volcanic outbursts, which was prolonged into the Lower Llandeilo epoch, was over, volcanic action ceased for a time, and an interval of repose ensued, during which the muddy sediments carried down by river streams, and sea currents, collected above the igneous and volcanic materials, and blended together in masses of enormous thickness. The remains of animals that frequented those seas are found imbedded in stratified volcanic ashes, and thus prove beyond a doubt that there were periods of rest, during which the marine animals returned to their accustomed haunts, the muds and sands of the sea bottom, while again and again, groups of marine animals were destroyed and buried by the immense quantity of ashes which, ejected from the volcano in action above, filled the air and, descending on these seas, sank through the waves.

Nowhere can the geologist study with greater advantage how the process of denudation is arrested by hard igneous rocks as compared with the softer aqueous rocks, with which they are associated, and how the former rise into hills and crags and the latter are eroded into plains and valleys. All the craggy heights which form so conspicuous a feature, west of Cader Idris, are composed principally of hard igneous or metamorphosed masses. It is hard to believe when we look upon Snowdonia that denudation has after all had more to do with the geological structure of the country than has elevation; but so it is, and in vain do we look for any original structure of the country, or for the original outlines of volcanoes, where the long process of waste by denudation has been so rife for ages.

The Caradoc beds set in to the south of the beautiful village of Dinas Mowddwy about ten miles from Dolgelly; and the Bala limestone crops out in the river Dovey. Fossils may be

found on Moel Benddu, Moel Dinas, and Pum-rhyd. The Bala limestone of Dinas Mowddwy thickens out towards the Bala country, and lies in the middle of the Caradoc group. It is underlaid by slates, below which again are the "ashbeds" of the geological surveyors, and it is overlaid by grey slates and grits; a limestone called Hirnant limestone; dark grey shales and black sandy slates.

The district round the town of Bala in Merionethshire, is celebrated as affording the most typical example of those Caradoc rocks which range over so large a surface of Wales. Gradually and without any abrupt break, they succeed the Llandeilo Flags of the Arenig and Aran mountains, and the government surveyors have assigned them a thickness, including the ash beds, of 10,000 feet. At Bala the central limestone is exposed in low hills near the town and lake. Here too, many very beautiful fossils have been found, and among them some rare star fishes and cystidea. Moel-y-Garnedd, Pen-y-rhiw, west of Bala, and Rhiwlas, are favourable localities for these fossils, but indeed every acre of ground around the lake is full of them.

In the valley of Hirnant, three miles east of Bala, a limestone occurs in the upper beds, called the Hirnant limestone; it takes its name from the beautiful valley of Hirnant and the stream which flows through it; the Bala limestone, which lies 1500 feet below it, being again succeeded by the volcanic ash-bed before alluded to, and which enabled Professor Jukes to trace its range from the valley of the Dee to the Conway. These ash beds owe their origin to the fall of ashes into the sea at a distance from the volcanic vent, through which were erupted the great masses of felspar, porphyry and calcareous ash, which, with the Bala strata, constitute the mountain masses of Snowdonia. The fossils of the strata below the Bala limestone may be all obtained at Tyn-y-fron, and Tai-yn-y-nant, east of Aran Benllyn. The trilobites Homolonotus bisulcatus and Trinucleus concentricus are those most commonly found here.

In the Hirnant limestone, fossils may be found below the

precipitous escarpments of Craig Moel-y-Dinas near Aberhirnant. At this latter locality the typical fossils of this limestone, Orthis Hirnantensis of McCoy, occurs, as well as another peculiar specimen—Orthis sagittifera. There is a beautiful walk along the brook of Hirnant through the mountains that unite the Arans and the Berwyns, crossing over to the valley of the Fyrnwy.

The town and lake of Bala should be visited not only by the geologist but by every antiquarian and naturalist, for it is surrounded by lovely and picturesque scenery, while hard by are old camps, and ancient ruins, and there is good ground around the lakes, and meres, for lacustrine and bog plants. The town is believed to date back from the Roman period, and our notes from old authors lead us to suppose that this conjecture is correct. There is a tumulus at the south-east end of the town called Tommen-y-Bala, which has furnished Roman coins; and the station of Caer Gai, where Roman pottery has been found, is mentioned by Camden, who says it was "built by one Caius, a Roman, of whom the common people of that neighbourhood report great things and scarce credible." Bala is also situated near the Roman road which ran by Meifod to Caernarvon (Segontium).

Bala Lake also possesses peculiar interest to the physical geologist on account of the great fault which extends from Cheshire by Yale, in Denbighshire, through Bala Lake, and passes on the west side of the Aran mountains, and east of Cader Idris, through the lake of Tal-y-Llyn, to the coast near Towyn. This fault has a downthrow to the north-west of some 3000 feet, and affects the Carboniferous rocks, as well as the Lower Silurians. The geologist will remark the lakes that lie on its route, and the great dislocations which traverse the Lower Silurians of this district in every direction.

This lake, under the name of "Pennelsmere," is also mentioned by Giraldus Cambrensis as the origin of the river Dee; and Camden appears to have visited it in the time of Queen Elizabeth, as he alludes to the "Gwiniad," as well as to the town of Bala. The Gwiniad, which takes its name from the

whiteness of its scales, is, I believe, peculiar to this lake.* It is a fish belonging to the Salmonidæ, and is closely allied to the Vendace of Loch Maben in Dumfriesshire, the Schelly of Cumberland, and the Powan of Perthshire, all of them being, I am informed by Sir William Jardine, closely allied species of the genus Coregonus.

There is a legend in Scotland to the effect that the Vendace was introduced to Loch Maben by the unfortunate Mary, Queen of Scotland; but old Churchyard,† whose poem "The Worthines of Wales" was published in 1587, the year Mary was executed, says:—

> "A poole there is thro' which the Dee doth pass,
> Where is a fish that some a whiting call."

There can be little doubt that these whitings are the gwiniad of Bala Lake.

At the meeting of the British Association at Exeter I called attention to the somewhat peculiar habitats of the Coregoni, the great lake trout (Salmo ferox), and the Chars (Salmo salvelinus, &c.). I have fished in and visited many of the lakes in Great Britain where these fish are known, and I never saw one in which they still exist that is not either a glacier lake, or rock basin, or that is not dammed, or otherwise surrounded, by glacial moraine matter. They are also inhabitants of the lakes of Sweden and Norway, which everywhere bear traces of the glacial epoch, and its close, and seem to me to be, like the Alpine plants that still linger among the mountains, fishes of that colder period, when the last of the glaciers still hung to the coombs of the Highlands of Scotland and Wales. Only this summer I assisted some friends in capturing the Alpine char (Salmo salvelinus), from a small

* Sir Philip Egerton took Salmo ferox in this lake in 1871.

† Mr. Thomas Churchyard, a poet of some note in his time, was a native of Shrewsbury. His principal work is entitled "The Worthines of Wales," In 1588 he published a work, bearing the following title, "A Spark of Friendship and warm Goodwill, that shews the Effect of true Affection, and unfolds the Fineness of this World." This tract is dedicated to Sir Walter Raleigh, whom the author calls his "Honourable Friend." This dedication is dated London, at my lodging, the 8th of March.

rock basin on the east side of Ben Hope in Sutherlandshire; and here, side by side with the fish, was the cloudberry (Rubus chamæmorus) and Saxifraga aizoides, growing profusely on the banks of the lake, 2000 feet above the sea. The Coregoni are found in many of the lakes in Switzerland.

In the lake of Bala grow the Isoetes lacustris, Ranunculus lingua, and Lobelia Dortmanna.

The Caradoc rocks of Caernarvonshire are so complicated, folded, and sometimes reversed, that it is impossible for the amateur to do more than gain a very limited idea of the intricate geology, the elucidation of which required years of hard study, and great labour on the part of Professor Sedgwick first, and afterwards of Professors Ramsay, Jukes, Selwyn, and other gentlemen of the Geological Survey. Still, an idea of the physical geology of Snowdonia may be attained by a steady examination of certain points, especially as Professor Ramsay's work on North Wales should now be in the possession of every student.

On leaving the Bala district, we recommend our brethren of the hammer to proceed to Bettws-y-coed, near Llanrwst, and to follow the valley of the Lledr up to Dolwyddelan, where they will see one of the most primitive villages in all Wales, and an old castle splendidly situated among noble hills. Fossils may be found on the castle rock itself. The Lledr rises in the wild glens of Yr Arddu and Moel Lledr, and between Castell Dolwyddelan and Yr Arddu, the geologist may detect a bed of felspathic calcareous ash, containing Bala fossils. These beds are believed to be the actual representatives of the thin limestone on the south-east and north of Bala, and of the limestone band in the river at Dinas Mowddwy; while the igneous and slaty masses underlying and overlying the fossiliferous ashbeds of Dolwyddelan, are now ascertained to be the equivalents of the thin ashbeds and slates which underlie and overlie the limestone of Bala. The fact is, that the Dolwyddelan country was nearer than Bala to the volcanic centres from whence were derived the flows and eruptions of felspathic lavas and ashes, while Snowdon itself lies, if not within the old volcanic centre, at all events very near it.

In going from the village of Dolwyddelan to Capel Curig, we may pass below Moel Siabod and observe the Caradoc fossiliferous rocks which form an anticlinal in the moors between Moel Siabod, and the Valley of Dolwyddelan. The crest of Moel Siabod is a great dyke of greenstone which has been erupted through the stratified ashes and slates of the Caradoc rocks. The greenstone forms the rocks above Llynfael, and alters, and metamorphoses, the slates through which it has been erupted. Here, as on Snowdon, the botanist finds none of the rare plants on the greenstone crags; some grow however on the north-western slope, on the equivalents of the Bala limestone. Among them we may mention Saussurea alpina, which grows in moist places on the ledges of the rocks, while the Lobelia Dortmanna, and the rare but insignificant awlwort (Subularia aquatica) grow on the fringes of the lakes.

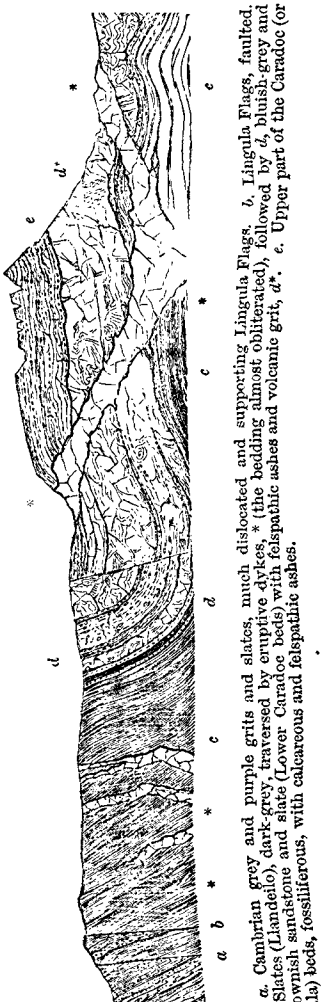
The scenery around Capel Curig is not to be surpassed, and there are numberless geological and botanical excursions to be made. It is an excellent place to choose for head-quarters, when making a protracted examination of this country. Many years ago I studied the district between Capel Curig and Bettwys-y-Coed, and from thence to Llanrwst, and there are sections where the minor undulations of the country may be made out, and where the interstratifications of ashes and igneous rocks and slates may be observed. After arriving at a certain comprehension of the physical geology about Dolwyddelan, the explorer should ascend Snowdon, and from thence, single out the Caernarvonshire mountains, Carnedd Llewelyn, Carnedd Dafydd, Moel Hebog, and Y-Glyder-Fawr, remembering that these last mountain masses consist of igneous and volcanic products, interstratified with beds of the age of the Caradoc sandstone and Bala limestone, while the outlying ranges of Cader Idris, the Arans, Arenigs, and Moelwyn, are composed of igneous materials interstratified with rocks of Llandeilo age. It is well too to look across to Anglesea and at the low country near Bangor and Caernarvon, where denudation, probably by ice action, has cut down the strata to Cambrian, and Gneissic

rocks, and to reflect on the vast masses of stratified deposits denudation has removed from above them.

The geologist should also recollect that the rocks of the Snowdon area are merely a repetition on a large scale of the Dolwyddelan trough, and that in the words of Professor Ramsay "the grandest part of this country both as regards the scale of the igneous phenomena and the consequent magnificence of its scenery is owing to the hard and soft layers concentrically interbedded in a great trough, shown in the easterly dips of the slates, grits, and traps, on the flanks of Moel Hebog, Snowdon, Y Garn, and Carnedd Dafydd, while the opposite inclination of the rocks on the summit of Y-Glyder-Fawr, Y Trifan, and part of Carnedd Dafydd forms the eastern side of the basin."

I have paid several visits to this delightful district, and some years ago, in company with my friends, the Rev. R. Hill and Professor James Buckman, I carefully observed the geology, and botany, of Snow-

SECTION ACROSS THE SNOWDEN RANGE. Snowdon, 3571 feet.



a. Cambrian grey and purple grits and slates, much dislocated and supporting Lingula Flags. *b*, Lingula Flags, faulted. *c*, Slates (Llandeilo), dark-grey, traversed by eruptive dykes, * (the bedding almost obliterated), followed by *d*, bluish-grey and brownish sandstone and slate (Lower Caradoc beds) with felspathic ashes and volcanic grit, *d**. *e*. Upper part of the Caradoc (or Bala) beds, fossiliferous, with calcareous and felspathic ashes.

don and its neighbourhood. We procured the services of William Williams the well-known botanist, and Llanberis guide. I could not ascertain from him whether there was any section of the Llandeilo beds where fossils could be obtained, although he took me to several localities where Caradoc fossils might be found, and in search of them, ventured to one of the most dangerous spots on the crags of Moel-y-Wyddfa. Williams was a most daring cragsman, and my companions will not easily forget seeing him on the precipitous escarpment of Moel Siabod, searching for the Saussurea alpina, and the Woodsia fern (Woodsia ilvensis). The purple Saxifraga oppositifolia was found by William Williams on Glyder-Fawr. It grows on the Pyrenees, and on the Matterhorn above the Smutz Glacier. Williams was afterwards killed by falling down the precipice of Moel-y-Wyddfa, when searching for the Woodsia.

I do not know whether Williams left behind him any account of the localities where he obtained his specimens of the rarer plants of Snowdonia, for he owned to us that several of the old stations were completely destroyed. The spiderwort (Anthericum serotinum) grew no longer among the crags above the Devil's Kitchen, though there was a station on Carnedd Dafydd where he obtained specimens worth half a guinea each. The Woodsia ilvensis grew in 1861 on a rock above Llyn Cwm, but in a locality only practicable for goats. Williams was an ardent lover of nature, and thoroughly appreciated a day's ramble with a botanist or geologist. It may be well to mention here for the information of entomologists, that on questioning him as to the habitat of the rare beetle, Miscodera arctica, he informed me that the most probable locality for finding it, was on the Beddgelert flanks of Snowdon, and that it was never seen far below the summit. Sir William Guise took this beautiful insect near the summit, on the ascent from Pen-y-gwryd, and by carefully turning the most likely-looking stones succeeded in taking also other rare coleoptera.

The Welsh Char (Salmo salvelinus), known as the Torgoch or Red Belly, is found in Llyn Cawellyn, near Snowdon. When I was there last a number had been taken with a net.

Snowdon was held in high veneration among the ancient Britons; and we find Giraldus saying that he "must not pass over in silence the mountains called by the Welsh Eryri, and by the English Snowdon, or mountain of Snow."

It is not probable that he and Archbishop Baldwin made the ascent; but he seems to have been bamboozled by the natives; for he informs us that a lake on Snowdon "is noted for a wonderful and singular miracle; it contains three sorts of fish; eels, trout, and perch, all of which have only one eye, the left being wanting." Edward the First held "a triumphant revel upon Snowdon, and then adjourned to conclude the ebullitions of joy for victory by solemn rites upon the plains of Mefyn." Camden visited Snowdon personally. Mr. Pennant's description of a tour, made in 1778, is extremely graphic.

It appears that the Lower Silurian rocks of Lleyn, although associated with innumerable masses of volcanic rocks, are not altered and metamorphosed to any great extent. They are found to be baked like those at St. David's, just at their junction with traps and greenstone; but they are not metamorphosed like the crystalline and so-called Cambrian rocks of the western coast of the peninsula. Caradoc fossils occur here in great abundance in beds which overlie the Llandeilo beds of Llanfaelrhys. The neighbourhood of Boduan and Pen-yr-alt north of Pwllheli, is very rich in these fossils, especially Boduan, where Orthis flabellulum, retaining the shell, is found in millions at Dolbenmaen; also rare fossils may be obtained as well, at Plas Penrhyn, Pwllheli, and other places. It is difficult to make out the physical geology of this country, as it is traversed to a great extent by trap, and obscured by drifts.

Intrusive igneous rocks are seen to be developed in many places where the removal of the drift deposits allows the underlying rocks to become visible. Criccieth Castle stands on a felspar rock. The great cliff of Trwyn-y-gorlech is a hornblendic greenstone. The peaks of Yr-Eifl consist of a syenitic porphyry. The Boduan rocks are a kind of greenstone, so also are the cliffs between Llanfaelrhys and Porth-Ceiread. Every-

where in this district the so-termed Cambrian rocks are much more metamorphosed than the Silurian strata.

According to Rowlands ("Mona Antiqua," 159), Criccieth Castle occupies the site of an old British encampment. The castle itself is said to have been repaired by Edward I. Its architecture resembles that of Dolwyddelan Castle.

Passing over to Anglesea, we find that the Parys mountain is a mass of volcanic rocks which penetrate and traverse Caradoc strata. The rocks have evidently been much fissured, and the fissures infiltrated with quartz and other minerals. This rugged hill is the highest point in the island, and is famous for its copper mines, the stores of copper it furnishes having once been so valuable, that in the early part of the century 20,000 tons were annually extracted. These mines were probably first worked by the Romans, a round cake of copper bearing a Roman stamp having been found at Llanfaethla.

The Caradoc rocks on which Conway Castle is built, dip south at an angle of 60 degrees, and contain Bala limestone fossils. This district is full of faults, and black slates of Llandeilo age are faulted through the Caradoc beds near the castle. Carboniferous, Upper Silurian, Lower Silurian, and Volcanic rocks may all be seen and student within a walk of Conway.

The Snowdonian hills which run from Moel Hebog by Carnedd Llewellyn to Conway, are composed of Caradoc formations, interstratified with submarine lavas and volcanic ashes. These have all been uplifted into a series of mountains, the beds of which are thrown into great anticlinal and synclinal curves, rising into lofty eminences in Carnedd-Dafydd, Carnedd Llewellyn, Moel Siabod, Moel Hebog, and Y Glyderfawr, and then sweeping in sharp curves beneath the rocks of Denbighshire, Llandudno, and the bed of the sea. The rocks which constitute a part of the low lying strata near Llandudno and Conway, as well as those of Cwm Hewart, Maesdu Bryn Gosol, and of the neighbourhood of Dyganwy, are but parts and portions of the uplifted strata which crown the peak of

Snowdon, and rise to a height of 3571 feet above the sea. Nor are the volcanic rocks which enter so largely into the constitution of the mountain masses of Carnedd Llewellyn and Snowdon, absent from the less hilly country around Llandudno. The ancient site of Dyganwy Castle is a volcanic rock which was erupted through the strata of Cwm Hewart, and appertains to the Caradoc period.

The old fortified town of Conway, was formerly supposed to be the Conovium of the Romans mentioned by Antoninus, but the site of that station is now generally acknowledged to be Caer Rhun, three miles above Conway, at Aber-Conway. The Conway river was celebrated in Roman times for British pearls, derived from the freshwater Unio Margaritiferus, a mussel which abounds in its waters. Camden's account of the origin of the pearls is curious. He says that "the river breeds a kind of shell, which being impregnated with celestial dew produces pearl."

Giraldus and Archbishop Baldwin, did not visit Conway, but "crossed the river Conway under Diganwy, leaving the Cistercian Monastery of Conway on the western bank of the river, to our right hand." The castle and the embattled walls of the town were built by Edward I., in 1284; and, according to Leland, the castle was built upon the spot once occupied by the monastery alluded to by Giraldus. It was to Conway Castle that Richard II. came from Milford Haven, on his return from his Irish expedition; and from it he was driven by famine to a prison at Flint Castle, there to be told by Henry Bolingbroke, that "he would help him to rule better the people he had ruled so harshly for two-and-twenty years."

Again, during the civil wars, we read, that Archbishop Williams garrisoned the castle for the king, but afterwards deserted the Royal cause and joined the Parliamentarians. The fortress was not dismantled until the time of Charles II., when the work of destruction was carried out by the profligate Earl of Conway, who stripped the noble pile, and transported the timber, iron, lead, and other materials to his estates in Ireland.

There are still some remains of the ancient Castle of

Diganwy, near Conway, which also bore the English name of Gannock. It was standing when Giraldus Cambrensis made the tour of Wales, and mention is made of it according to Hoare, in the Welsh Chronicle, as early as 810. The walls crossed the space between two hills and ran up their sides. King John "came to the Castell of Diganwy," according to Powell, in 1210, and remained there awhile "until the English souldiers, were glad to taste horsse flesh for pure neede," and in 1245, King Henry III. experienced great distress at this place, the king with his army being stationed at Gannock, where they were cut off by the Welsh from their supplies, and lay in their tents "watching, fasting, praieing, and freezing with cold." Diganwy was totally dismantled in 1262 by Llewellyn.

The castle slopes are celebrated for the Maiden pink (Dianthus Deltoides). We saw it blossoming there, a few summers ago, when examining the trap hills of Dyganwy and Bryn Gosol.

THE BERWYNS.

In the Berwyn country, the Caradoc or Bala beds are much thinner than their equivalents in Merionethshire. The highest interbedded igneous rocks represent the thin ash beds of the Bala district, and also the thick masses of interbedded ash beds and felstones of Snowdon.

On the east flank of the Berwyn mountains, the Caradoc deposits stretch from the river Fyrnwy on the S.S.E., by Alt-y-Maen, Alt-y-Gader, and Coll-Melwyn, to the river Tanat on the N.N.W. The structure of this district is that of an undulating hilly country, and it is most rich in fossils of all kinds.

A very instructive walk of about thirteen miles may be taken from Bala to Corwen. This village lies at the foot of Moel Ffenlli, the most northern hill of the Berwyn range, and which attains a height of more than 2000 feet. Just beyond Corwen is an instructive outlier of mountain limestone full of joints. Five miles westward is the fine waterfall of Pont-y-glyn, which flows in a fissure of Caradoc strata. Fossils and especially corals may be obtained here.

Corwen is associated in many ways with the memory of the great Welsh chieftain, Owen Glyndwr. His birthplace, Sychnant, is about three miles distant. Holinshed relates that on the night before his birth his father's horses were found up to their bellies in blood. Caer Drewyn was used by Glyndwr as an encampment, although of far older date than his times. Rug, in the vale Edeyrnion, was a part of Glyndwrdwy, his possessions on the Dee, and it is said that some personal relics of one, "not found in the roll of common men," are preserved there. Near Llanfyllin the Bala beds are very fossiliferous, and the strata are thrown into a vertical position well worth observing.

In the valley of the Ceiriog, south of Llangollen, the Bala group, rich in fossils, and especially in Bellerophons, is exposed on either side of the River Tenw, between the New Inn and Pont-y-Meibon, at which latter locality there are also ash beds. The lowest beds of Bala limestone at Hafod-y-galley contain fossils, so also do the middle or central group of strata in the quarries of Nantyr and Llanarmon. The uppermost rocks of this limestone are exposed at Cefn-coch on the north, and afford many beautiful corals and bryozoa.

Those who really wish to study these strata in detail should take the route from Welshpool. The Breidden Hills, N. E. of Welshpool, run along a line of eruption, which separates the Lower Silurians of the Tanat and Fyrnwy district from the Upper Silurians of the Long Mountains. The section *par excellence* to be recommended, is the instructive one given by Sir R. Murchison in his "Silurian System," which takes the investigator by Powys Castle, the Gaer, over the Broniarth Hills to the vale of Meifod, and then across the Caradoc tract to Llanrhaidr.

The Castle of Powys is the "Castell Coch" (Red Castle) which stood so many a siege when the residence of the Princes of Powys. Its historical records are too voluminous to give here anything but a few notes. We read of Offa, King of Mercia, driving the kings of Powys from Pengwern (Shrewsbury) beyond the Wye; but the earliest historical notice of

the castle itself is about 1109, when the building was commenced by Cadwgan, Prince of Powys, who was, however, murdered by his nephew, Madwc, before it was completed. It seems that one of his sons named "Gruffydh," met Giraldus and Archbishop Baldwin at "Oswaldestree," or the tree of St. Oswald (Oswestry), and there they were sumptuously entertained "by William, son of Alan, a noble and liberal young man." In the days of Richard I., about 1195 or 1196, Hubert, Archbishop of Canterbury, is said to have besieged this fortress; and in 1233 it was dismantled by Llewellyn-ap-Jorwerth, a prince of South Wales. It came again into the possession of the family of "Gruffydh" through a lady, Hawys, and it continued for several generations in the possession of her posterity, fighting a good battle for Charles I. in 1644.

The Caradoc range of hills, near Church Stretton in Shropshire, consist of Caradoc strata traversed and altered by igneous rocks. This range stretches from the hill of Ragleath on the S. W., by Caer Caradoc to the Lawley, N. W. Unaltered sedimentary rocks may be seen at Cardington and Hope Bowdler. The valley of Stretton runs along the line of a tremendous fault, for immediately opposite the hills of Caradoc rocks, and only just across the valley, behind Church Stretton, are the Longmynd Cambrians. At Botville, on the north-western flank of Caer Caradoc, there is a mass of Wenlock limestone jammed between the Longmynd rocks and the Caradoc sandstone, a proof that considerable earthquake movements have affected the whole country since the deposition of the Upper Silurians.

Owing to the great fault just alluded to, and the protrusion of volcanic rocks to the surface, the relations of the Caradoc rocks to the underlying Upper Llandeilo Flags are not exhibited in the Church Stretton district. The best section for studying their upward development and their position as regards the Upper Silurian series, is that given by Murchison, and which runs from the east flanks of the Caer Caradoc, and the Lawley, by Hoar Edge, Chatwall, and Gretton, to Apedale under Wenlock Edge.

In the Hoar Edge we have the coarse lower grit beds

quarried, and from thence we ascend by Enchmarsh, and Gretton, to higher and higher beds. Both these latter localities are good places for fossils. The examination of this section may be perhaps best undertaken from Church Stretton.

The geologist should also visit the Onny section, near the

THE CARADOC RANGE.

(Sketched by Mrs. Stackhouse Acton.)

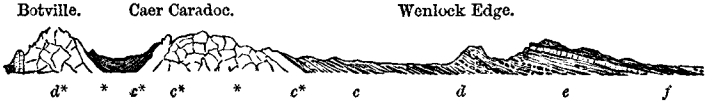
The Lawley. Caer Caradoc. Hope Bowdler. Broccard's Castle. Ragleath.

Craven Arms station, between Church Stretton and Ludlow. This section is held in high esteem, and commences at Stretford Bridge with Wenlock shale, and passes by Wistanstow north of Cheney Longville and Horderley, to Hillend at the base of the Longmynds. Near the junction of the Caradoc beds with the May Hill and the Wenlock shale, the beds are full of that beautiful trilobite, Trinucleus concentricus (T. caractaci of Murchison). Between this place and Horderley are reddish beds full of characteristic shells of the Caradoc sandstone, and the collector may easily obtain many of the typical forms, and especially that fine fossil, the Strophomena grandis, with the typical trilobite Trinucleus seticornis.

In passing on to the Cambrian rocks from the Caradoc strata at Cheney Longville, the geologist must be careful not to confound the Upper Llandovery or May Hill rocks, which rest, like an ancient sea beach, against the south flank of the Longmynds, with the Caradoc strata. They may be known at once by the Pentameri, which are so characteristic of these rocks, and which occur in abundance in them.

The following directions may be useful to the geologist visiting the Onny section, as the whole country is greatly faulted, and it is useless attempting to do more than examine the broken strata where best exhibited. The Hoar Edge grits and Horderley limestone are Caradoc rocks; so are the Cheney Longville flags; and likewise the trinucleus shales of the river Onny. At Cheney Longville footbridge the Caradoc shales

RELATIONS OF CARADOC SANDSTONE TO THE UPPER SILURIAN ROCKS IN SHROPSHIRE.



* Eruptive rocks. *c**. Caradoc Sandstone altered by eruptive rocks. *c*. Caradoc Formation, surmounted by Llandovery Limestone. *d*. Wenlock rocks. *e*. Ludlow rocks. *f*. Old Red Sandstone. *d**. Vertical Wenlock Limestone (Botville).

containing Trinucleus concentricus, with other tribolites, ampyx, and lichas occur, and overlying them are the May Hill or Upper Llandovery rocks, with Pentamerus, and Atrypa reticularis, and Petraia, a very characteristic coral of the May Hill group. There is an overhanging holly-tree, which stands over the exact line of junction, but no Caradoc fossils cross this thin line into the unconformable May Hill rocks. The Caradoc rocks of the Onny district may be examined in other localities, at Soudley, and Tickleston, and Bellerophons, and small Nuculas occur in them. The purple shale in the Onny section which overlies the thin pentamerus limestone is known as the Tarannon, or Woolhope shales, and is largely developed in North Wales.

The Wrekin has much the same geologic history as that which we have already traced in describing the formation of the Snowdonian range. Lavas were poured into the Caradoc rocks and were cooled and crystallised. Then long ages succeeded, during which Upper Silurian corals built their limestone masses around and over the cooled traps; while, in still later ages, the Coal measures covered up the Upper Silurian and Lower Silurian formations and their dark grey traps. After the close of the Carboniferous period another interval of volcanic agencies and earthquake movements commenced, for the principal elevation of the Wrekin, like that of the Malvern Hills, is of Permian date.

Caradoc rocks do not overlie the Upper Llandeilo beds which range from Builth to Llandegley. They are altogether wanting. The Government surveyors also supposed that the Caradoc strata were deficient on the left bank of the Towy, but on the right bank, in the hilly tracts on the north and west, they are recognised by their fossils and seen to overlie the Llandeilo flags. It is important to bear this in mind, although Mr. Salter ascertained that certain Caradoc strata, wholly unlike those of North Wales in a mineralogical point of view, but containing their characteristic fossils, occur on the left bank of the Towy near Llandovery, as, for instance, at Cilgwyn Park and under Blaen-y-cwm near Llangadock.

The Gogofau gold mine, amidst hard Caradoc grits, may be visited from Llandovery. There are many relics at Dolaucothy, the seat of Mr. Johnes, of the Romans, who worked this mine, and who appear to have had a station on the spot. Several gold ornaments, amongst others a gold necklace, have been discovered in the immediate neighbourhood, associated with Roman pottery. A good expedition may be made from Llandovery over the Caradoc hills to the west. The naturalist provided with an Ordnance Map of the country and a compass, should follow the river Towy up to the mountains, past the lead-mines of Nant-y-Moen, to Twm Shon Catty's Cave. This cave is a fissure in the rocks, and in the pool

below it is a capital salmon and sewin cast. I found fossils in the rocks to the west of the cave, but they are very ill defined. At Nant-y-Moen the rocks are close upon a trap dyke, and we may meet with pebbles of greenstone in the river-bed above the mines.

For the lover of hill, and dingle scenery, there are many wild mountain walks of no ordinary character, in the tract of country between Nant-y-Moen, and Tregaron, and from thence to Rhayader by Strata Florida Abbey and Cwm Elan.

During the summer of 1865, I travelled over the mountain route from Llandovery to Tregaron with my friend, the late Rev. Jas. Hughes of Glan Rheidol in Cardiganshire, who had in his possession a portion of the once celebrated horn of the great Bannog ox, said to have been preserved in the Church of Llanddewi Brefi ever since the days of St. David. Anxious to investigate the history of this relic, we visited Llanddewi Brefi, where we received much information from the vicar, and ascertained that the portion of horn now in the possession of Mr. Parry, had been given many years ago to his uncle by the sexton of the parish. The following is the note in Gough's Camden. "The sexton showed him a rarity called Mathorn yr ych Bannog, which he said had been preserved there ever since the time of St. David, adding the fable of the oxen called Ychen Bannog which drew away a monstrous beaver dead." On examining this relic I found it to be a portion of the horn of Bos primigenius well fossilised. It is curious, too, that the legends of the great ox should be connected with the legends of the now extinct beaver which, from the accounts of Giraldus, must have inhabited the Teifi lake and river in the time of Henry II. Giraldus especially treats of the beaver, and the peculiar construction of their "castles" in the middle of rivers. He speaks of beavers abounding in Germany and the Arctic(?) regions, "in Germania Artoisque regionibus." He mentions also, that the river Teivi is remarkable for its salmon, which are finer and more abundant than in any other river in Wales, and he dilates on the peculiar manner of the salmon-leaping.

Camden says that the beaver was unknown in the Teifi in his time. This Teifi beaver was doubtless the same as the Castor Europæus which also inhabited the Thames, and the contemporaries of which have left so many of their heads and jaws in the peat marls of Cambridgeshire. The beaver is specified in the laws of Hywel Dda (A.D. 930) as the broad tail, to distinguish it from the otter or water-dog. There is a large tract of marsh and bog between Tregaron and Pont-rhyd-vendigiad which must have been a lake in no very remote times, and which is very likely to furnish the bones of this animal. In North Wales we find that Nantffrancon signifies the valley of the beaver.

There are some interesting legends connected with Llanddewi Brevi, although this lonely village is the last place one would have expected a saint to have selected for the working of miracles and the display of supernatural manifestations. It is a wretched place now, and it was no better in the times of Henry VIII.; for Leland describes it as "but a simple and poore village." And yet it was at Llanddewi that St. David, "so remarkable for his sanctity and religion," compassed a miracle which astonished even Giraldus Cambrensis, who was capable of swallowing any amount of astounding statements.

Here a Synod was held, about the year 519, "and all the bishops, abbots, and clergy of Wales, and many other persons, were collected thither on account of the Pelagian heresy." The people, it appears, declined to listen to the bishops, and the abbots, and the clergy of Wales, and made strong objections to accepting the Catholic faith, when it was determined to send for St. David, who joined the convocation and preached to some purpose, for "a snow-white dove, descending from heaven, sate upon his shoulders; moreover, the earth on which he stood raised itself under him till it became a hill." On the top of which hill a church was afterwards built, which remains to this day.

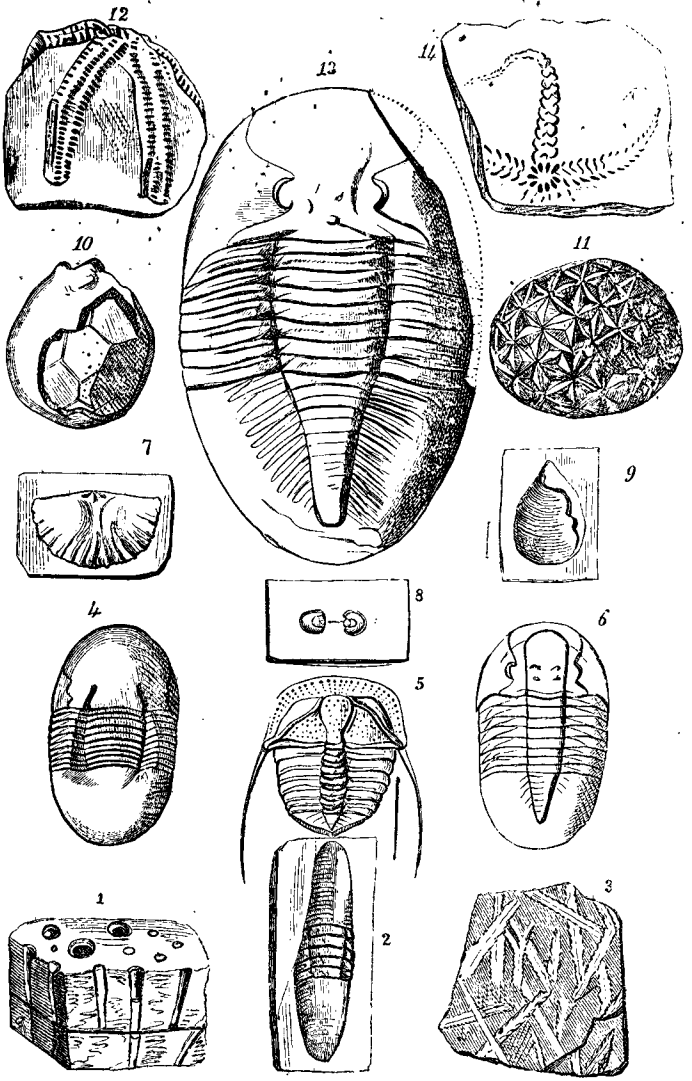
It is probable that the church of Llanddewi is built upon a volcanic dyke, for, although we could find no section, there

are several trap-like bosses between that place and Tregaron, and in the immediate vicinity we saw columnar portions of rock used for gate-posts. This dyke is of the Caradoc period, the time of its eruption, and the subsequent denudation of the country, dating from times far earlier than those of St. David. At Tregaron, the geologist will observe the way in which a vast mass of boulder clay, and till, once blocked up the outlet of the Teifi river, near the present bridge, and which no doubt once constituted the barrier of a large lake now silted into marsh and bog.

Between Tregaron and these lakes, we pass the ruins of the once celebrated monastery of Stratflur, or Strata Florida Abbey. It is difficult to imagine that a monastery, situated in this wild district, should have been, for a long period, the centre of civilization, the repository of the national records of Wales, and the burial place of many of the princes and nobles of the land. And yet it is a spot that might well have been selected by such severe recluses as were the Cistercian monks. Now, all that is left of this once revered sanctuary, is a single rich Norman arch, surrounded by neglect and desolation, and hard by is a parish church which might be the temple of a savage race, so mean and wretched is its structure.

The Abbey of Strata Florida was founded A.D. 1164, by Rhys Ap Gruffydth, Prince of South Wales, and his donations were confirmed by Henry II. It has been said that the Abbey was erected in 1184, but this is not probable, as we find Archbishop Baldwin, and Giraldus Cambrensis, passing the night there on their road to Llanddewi Brevi in 1188, and the building would hardly have been completed in four years. Giraldus also sent his library to Stratflur for safety. In 1238 Prince Llewellyn Ap Jorworth held a great assembly here. The abbey was burnt down in 1294 by the order of Edward I., and, although he afterwards granted the sum of seventy-eight pounds sterling to help to rebuild it, it never recovered its former grandeur, and was afterwards suppressed by Henry VIII. Leland, speaking of the monastery as it was in Henry's time, says "The Church of Strateflere is larg, side ilid, and crosse

PLATE II.



1. Scolithus worm-burrows.
2. Æglina caliginosa.
3. Diplograpsus pristis.
4. Illænus Bowmannii.
5. Trinucleus.
6. Ogygia Selwynii.
7. Orthis calligramma.
8. Agnostus Maccoyi.
9. Obolella.
10. Sphæronites munitus.
11. Echinosphærites Balthicus.
12. Palæaster asper.nus.
13. Asaphus tyrannus.
14. Protaster Salteri.

[*Page* 125.

ilid. By, is a large cloyster, the fraytry and infirmitori be now mere ruines. The cemeteri, wherein the counteri about doth buri, is very large and meanly waullid with stoones. In it be XXXIX. great hue trees." Dugdale has preserved many memorials of this abbey; but Camden merely alludes to it as a monastery of the Cluniacs.

It is interesting to observe the physical features of a peculiar district in the walk from the Teifi lakes to Rhayader, but there are few fossils to be met with. Caradoc fossils may be found between Rhayader and Builth, and among them is a typical fossil, Orthoceras vagans, one of those chambered shells, allied to the Nautilus, which were so abundant in the Upper Silurian seas.

Caermarthen stands on the Caradoc rocks, which stretch far and wide towards the north. They are singularly uninteresting to the geologist the whole way from Caermarthen to Aberystwith, by Lampeter, and I have never seen a fossil from these rocks all along this line of country. The old river drifts are instructive and worthy of observation.

In Pembrokeshire there is a section at Sholeshook, about a mile north of Haverfordwest, which has furnished some Cystidiæ and many other typical fossils of the Bala and Caradoc strata. The whole country is faulted to such an extent as to render it difficult to comprehend the position of the rocks. At Robeston Wathen, Caradoc fossils may be found in limestones; but here care must be taken not to confound the Caradoc limestones with the Llandeilo limestones of Llanddewi Felfry, and Lampeter Felfry, for there, as at Llandeilo, they are brought close together by faults.

ORGANIC REMAINS OF THE LLANDEILO AND CARADOC STRATA.

The "Silurian System" of Sir R. Murchison was the first work in which the fossils belonging to this great formation were classified, and in which the geological position they occupy was determined and assigned to them. Some of the shells, however, had been figured and described by Mr. James Sowerby, in his "Mineral Conchology."

As the present work deals only with the most typical forms, the reader should turn to "Siluria" for details and references, and consult the "Mem. Geol. Survey," vol. iii.

Among the fossils of the Llandeilo formation, Graptolites are very abundant, indeed in some localities they appear to have existed in such vast numbers as to have formed Carbonaceous matter in the rocks. These fossils are known only in Silurian rocks, the double Graptolites being typical of the Lower Silurian series. It was formerly believed that Graptolites were allied to the Pennatulidæ, but they are now supposed to be Hydroid Zoophytes, while some naturalists, again, consider that they belong to the Bryozoa (low forms of coral like Mollusks). Thus the question of their place in Nature is not yet settled.

There are several forms of the true coral in the Llandeilo rocks, and among them the well-known Chain coral (Halysites catenularius), which occurs so frequently in the Wenlock limestone of the Upper Silurians.

In the Llandeilo rocks appear also Orthoceratites Avelinii and O. encrinale, and the curved forms of Cephalopod, Lituites, and Cyrtoceras. Some forms of Brachiopoda are abundant, especially the Orthides. The Orthis is known by its straight hinge line; the simple plaited species are most characteristic of the Llandeilo and Caradoc beds. Certain forms of Gasteropoda, which include such animals as land snails, sea snails, whelks, volutes, cowries, &c., are found in the Lower Silurians.

The genus Euomphalus, allied to Turbo, occurs in the Llandeilo rocks, with Ophileta, and other genera. The true Bivalves, or Conchifers, are poorly represented; but Cucullella, and Ctenodonta, forms allied to Arca, and Nucula, have been determined from these old strata. Trilobites absolutely swarmed in the seas of both the Lower and Upper Silurian periods. The genera most typical of the Lower Silurian rocks are Asaphus, Ogygia, and Trinucleus.

Some beautiful forms of the Radiata occur in the Caradoc formation. A Cystidean (Echinosphærites) is found in the Caradoc rocks of Bala, and Sholeshook, near Haverfordwest,

and a beautiful Crinoid (Glyptocrinus basalis), with two species of Star-fish (Palæaster), have been found near Welshpool, at Meifod, at Bala, Corwen, and in other localities. Crinoids are quite common in rocks of this age in Canada.

Notwithstanding the delicate and beautiful organization of the Cystidea, Crinoidal animals and Star-fish, they all belong to one of the lower divisions of the animal kingdom, that of the *Echinodermata*. The Cystidea appear to have been low forms of the Crinoidea or lily-shaped, animals, as the arms and tentacula are very short, and in some cases entirely wanting. The true Crinoids, which have not yet been met with below the Caradoc rocks, must have somewhat resembled a highly developed polype, supported upon a long calcareous stem, and consisting of innumerable pieces of definite shape, which, combined, formed a complete internal skeleton. The stems and arms of the flower-like animal were capable of bending and sweeping in every direction, the arms acting as instruments for seizing the prey, and conveying it to the mouth, in the centre of the body.

The Star-fish are more highly developed than the Crinoidea, being capable of motion by suckers. In the Caradoc rocks the different organisms are more numerous and varied than in the lower rocks : new sponges, corals, bryozoa, brachiopod shells, conchifera, with many new gasteropoda, or sea snails, and pteropoda. Among the brachiopoda, we have the genera Rhynconella, Atrypa, Discina, and Strophomena, and among the Conchifera, the genera Ambonychia, Cardiola, and Ctenodonta. The Gasteropoda furnish many species of Murchisonia, with Holopella, Cyclonema, and Patella. The typical genera of the numerous Trilobites of the Caradoc rocks are Acidaspis, Harpes, Trinucleus, Illœnus, Cheirurus, and Asaphus.

It will be seen that as yet no evidence has been detected of the existence of fresh water lakes or fresh water deposits, although we may feel assured that they were not wanting during the Lower Silurian epoch ; neither have we any proofs of the existence of vertebrate animals ; even fishes have not

yet been discovered, notwithstanding that the remains of many types of other existing marine animals have been disinterred from the rocks.

As we ascend the geological ladder in the series of stratified deposits, and read later chapters in the earth's history, we find that certain forms of animal life, which existed during the earlier epochs, dwindled, decayed, and gradually died out. Such is the case with the whole group of Graptolites, so abundant in Lower Silurian strata, but which are unknown in formations more recent than those of Upper Silurian strata.

CHAPTER V.

MIDDLE SILURIAN ROCKS.

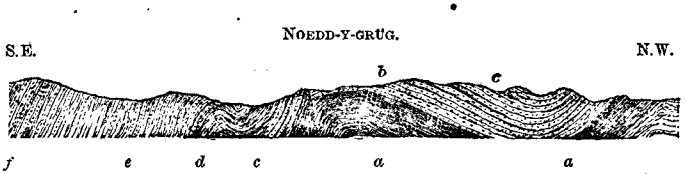
Lower Llandovery Rocks—Noedd-y-grug—Mallwyd—Pont-y-Mynach—Signs of Glacial Action around Llyn Rheidol—Plynlimmon—Rhayader Gwy—Staff of St. Cyric in St. Harmon's Church—Upper Llandovery or May Hill Sandstone—Church Stretton—Stokesay Castle—Conglomerates at Old Radnor—The Malvern Hills—Section in Malvern Tunnel—Discovery of Pterygotus problematicus at Eastnor—Howler's Heath—Fungi of—The Lickey—Quartz Rock of—May Hill—Marloes Bay—Tarannon Shales—Llandrindrod—Cefn Llys Church—Fossils of Middle Silurian Rocks.

		Typical Fossils.
Tarannon Shales.		Rare. Wenlock forms.
Upper Llandovery Rocks, or May Hill Sandstone.	*Shells.*	Stricklandinia lens. Pentamerus oblongus. P. liratus. P. undatus. Nucula Eastnori.
	Trilobites.	Few, and not characteristic of the formation.
Lower Llandovery Rocks.	*Shells.*	Atrypa crassa. A. reticularis. A. hemispherica. Murchisonia. Orthoceras. Lituites. Cyrtoceras.

In the above classification of the Middle Silurian rocks, I have followed the advice of the late Mr. Salter, who divided them both from the true Lower Silurian deposits on the one hand, and the typical overlying Upper Silurians on the other.

LOWER LLANDOVERY ROCKS.

These strata derive their name from the pleasant town of Llandovery in Caermarthenshire, round which they are exposed. They are also well exhibited to the north and west



a. Schists, &c., representing the Caradoc formation. *b.* Lower Llandovery rocks (Llandovery Sandstone). *c.* Upper Llandovery rocks: equivalent of the May Hill Sandstone. *d.* Tarannon Shale, or 'pale slate.' *e.* Wenlock and other Upper Silurian strata, without subdividing limestones. *f.* Base of Old Red Sandstone. (Compare with Section, Sil. Syst. pl. 34, f. 3.)

of Llandeilo. These rocks are unknown in the typical Silurian country, and at Llandovery it appears that they are unconformable both to the underlying Caradoc rocks, and to the overlying May Hill beds (or Upper Llandovery rocks) and Upper Silurians. The best district for studying the Lower Landovery beds is the singular, bare, tract of hilly country called Noedd-y-grug, and on the Mwmfre hills to the north-east of Llandovery.

It is a fine walk for a geologist to cross from the Old Red Tilestones of the Mynydd-Eppynt on the south-east by Castell-Craig-gwyddon, over Noedd-y-grug to Cerrig-gwynion on the north-west. It is one of Murchison's "Silurian System" sections, and an extremely difficult bit of ground to unravel. Between Noedd-y-grug and Cefn-y-garreg, the strata are curved into basin-like depressions, and this hollow should be visited in order to understand the marked and peculiar character of this rugged tract.

Some years ago I had the pleasure of conducting my friend Prof. Harkness over this section, and he was much struck with the peculiarity of the basin-like depressions and synclinals between the hills. At Pont Dreinan, the large hollow at the foot of Cefn-y-garreg, Pentamerus oblongus, Petraia, and other May

Hill sandstone (Upper Llandovery) fossils, occur in the shelves of the strata, that crop out one above the other. The best method of tracing the beds downwards is to follow the course of the stream, by the gorge of Glynmock, where the Lower Llandovery rocks are seen to underlie the Noedd-y-grug pentamerus rocks. *Atrypa crassa*, a typical Lower Llandovery shell, is found at Cefn-y-garreg in coarse gritty slates in the beds below the May Hill sandstone.

Some species of fossils occur for the first time in the Lower Llandovery rocks, such as the genus Pentamerus and Atrypa reticularis. Fossils are rare, however, and the best specimens I saw from this district were in the possession of Miss Hughes, daughter of the Bishop of St. Asaph, and there were also a few at the College, including Atrypa crassa, a Trilobite, a Pentamerus, and a sponge. To the east of Llandovery the rocks of this formation rise into the undulations of Noedd-y-grug, and then rolling over to the west, cap the hills and higher grounds of South Wales, where later investigations prove that they occupy large tracks marked as Caradoc beds on the maps of the survey. Besides the localities already mentioned, the geologist should make a point of visiting Cefn Rhyddan, two miles S.S.W. of Llandovery, where there are vertical flagstones with the characteristic fossil Atrypa crassa, also found at Mandinam, near Llangadock.

The trained geologist who may wish to try his skill at constructing a geometrical section of a difficult piece of ground, may take the country from the Llandovery valley on the north, to the terrace in Cilgyn Park, and Blaen-y-Cwm on the south. It will reward him by its complexity of structure; and in a hilly tract of ground, not three miles square, he may gather in succession, Caradoc, Lower Llandovery, Upper Llandovery, and Wenlock fossils. We must not fail to note the old river Drifts along the Towy side, and the evidence we perceive, on the Builth railroad, of the way in which great masses of boulder clay with well scored and grooved blocks of stone have been deposited.

The Upper Llandovery strata are wanting in North Wales,

(so also are the Lower Llandovery series in Siluria proper), but the Lower Llandovery rocks have been determined in this part of the country, and it has been ascertained, both from their position and fossils, that they overlie the Caradoc rocks to the south-east of Bala, and thicken greatly in their strike southwards. They do not occur between Bala and Conway. In Merionethshire, fossils are almost unknown in these beds, and the strata may be distinguished from the underlying Bala, or Caradoc, slaty rocks by their sandy appearance. They are also marked by a conglomerate, showing that an alteration was taking place in mineral depositions; while a certain change in the fossils informs the palæontologist that new species of shells and trilobites had succeeded the species common to the Caradoc seas. There is no apparent unconformability between the Bala beds and the Lower Llandovery in the Merionethshire district.

When visiting the neighbourhood of Bala, the geologist should extend his excursions to Mallwyd, where, besides the fine scenery, he will also have an opportunity of making out the correlation of the Lower Llandovery deposits with the Caradoc rocks of Dinas Mowddwy and the overlying Tarannon shales.

The Lower Llandovery strata have also been determined in Montgomeryshire, in the Meifod and Welshpool districts. They occur in limestone bands with Pentamerus, and Petraia, and associated with conglomerates, on the banks of the Fyrnwy, south-west of Meifod, and also at Guilsfield, near Welshpool. Mr. Salter has quoted fossils as having been collected by himself and Prof. Sedgwick from several localities, many of them being undescribed species.

Strata of this age, hard, gritty, and unfossiliferous, overlie, in many places, the Caradoc rocks of Cardiganshire, Caermarthenshire, and Radnorshire. They cap the heights of Plynlimmon, and of many of the highest hills in that country. The best rule in determining the line of their separation from the underlying rocks of the Caradoc series, is to look out for the conglomerate beds and sandy slates of the Lower Llandovery.

There is a well-known waterfall and bridge about twelve miles from Aberystwith, known as the Devil's bridge. The place derives its Welsh name of Pont-y-Mynach, or the Monk's bridge, from the fact that the old bridge, for there is a double arch, was supposed to have been the work of the monks of Ystradfflur, or Strata Florida Abbey. The romantic scenery of the Devil's bridge and Pont Erwyd may well invite the geologist to enjoy the beauty of its defiles; but we cannot recommend the physical geology to a stranger, and although a few fossils, including the characteristic Atrypa crassa, have been found at the rocky promontory where the Mynach empties its waters into the Rheidol, they are extremely scarce. The rocks are hard unfossiliferous slates and grits, and, in fact, the whole district is so contorted and undulating that, in the general absence of fossils, it is impossible to arrive at any definite conclusions: Thus the discovery of two or three fossils here is of great importance, and the evidence proves the capping, at least, of these Plynlimmon strata to be of the same age as that of Noedd-y-grug, and the grits of Dolfan, between Builth and Rhayader.

The botanist will find some good ferns among the black, dripping rocks that overhang the Rheidol at Pont Bren, near the Devil's bridge. Hymenophyllum Wilsoni grows there in considerable abundance, and Cistopteris fragilis flourishes on the bridge itself.

The Lisburne lead mines are the most important in Cardiganshire, and it appears that the veins of ore and dykes of trap-rock run from east to west, while from the inquiries I made, it seems that the lead ore is always more or less associated with volcanic infiltrations of later date than the age of the deposition of the Lower Llandovery strata.

In going from the Devil's bridge to Plynlimmon we may take the route through Yspytty Cenfaen, which, with Yspytty Ystradmeirig between Hafod and Tregaron, are believed to have been Hospitia, or places of shelter, established in this wild region by the monks of Stratflur. The church of Cenfaen, or Cefn-y-faen, is said to have been erected within an ancient

circle of large stones, or otherwise the name may apply to the rocky ridge behind the church. By following the course of the river Rheidol, from the falls of the Castel, and Rheidol, at Pont Erwyd to the lake called Llyn Rheidol, we may see some rock sections, and also the signs of ancient ice action along the hill sides. The action of streams too, among the upper slopes of the hills, lay bare a sandy drift among the bogs and morasses. It contains drift stones and pebbles, which, as far as I know, do not belong to the district, and which eventually will probably prove to be glacial marine drifts on the flanks of Plynlimmon. Crossing Plynlimmon to the Lyn Havren, the conglomerates and sandy slates between the lake and Llanidloes are, for the most part, Lower Llandovery deposits. The Severn rises on the north-west of the hill, but I do not recommend crossing Plynlimmon from Pont Erwyd in order to reach the sources of the river. The walk is long and fatiguing, and the ground absolutely dangerous from morasses. The Rheidol ascent is far better.

At Rhaiader Gwy, the "cataract of the Wye," we find beautiful rock, river, and mountain scenery, good botany, interesting archæology, and some very difficult physical geology not yet fully worked out. Nothing remains of the Castle save the fosse; but Welsh archæologists inform us that the fortress was built by Rhys-ap-Gruffydd, the same Prince of South Wales who met Archbishop Baldwin and Giraldus Cambrensis at Radnor in 1188, and who erected the castle about the year 1188, to check the incursions of the Normans. Powell, however, in his "Welsh Chronicle," says:—"At this time (A.D. 1178) the Lord Rees did build the castell of Rayder Gwy, that is to saaie, the fall of Wye; for the river Wye falleth there over a great and high rocke." The ancient name of the Rhayader district is Warthrenion, and according to Giraldus it was famous in the days of Henry II. for prodigies and miracles. The archæologist will find a small church, now called St. Harmon's, three miles from Rhayader, which, according to Sir R. Colt Hoare, is the church of St. Germanus of Giraldus. Here there was a staff of St. Cyric, which was especially efficacious

in the removal of glandular swellings, if "devout application to the staff were made," "with the oblation of one penny." The staff, however, was somewhat particular about receiving its due tribute, as it happened in the days of Giraldus that a patient presenting a halfpenny the disease subsided only in the middle; and another coming with the promise of a penny was cured, but failing to fulfil his engagement, his sufferings returned, and he had to pay threepence to obtain a cure.

Camden says that near "Rhaiadr Gwy there is a vast wilderness, dismal to behold by reason of many crooked ways and high mountains, into which, as a safe place of refuge, that bane of his native country, King Vortigern (whose very memory the Britons curse), withdrew himself." This "wilderness of crooked ways" is believed by local authorities to be the glen of the Marteg stream, and the Nannerth rocks beyond St. Harmons.

From Rhayader Gwy I particularly recommend a visit to the Drygan mountain, which consists of Lower Llandovery rocks, apparently metamorphosed in some places, and where evidences remain of the last of one of the glaciers among the Welsh mountains. On the west side is a little glacial lake surrounded with moraine matter. This lake contains the finest trout in the country, and the legend is that they were introduced into it by St. Cyric. They feed upon a small leech, and a fresh-water shell, one of the Lymneas.

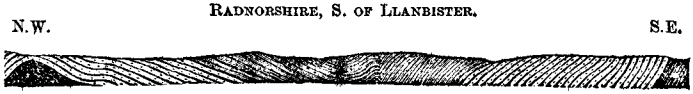
The geologist may examine the hills of Dolfan, Rhiwgraid, and Gwastaden, the summits of which exhibit Llandovery sandstones and conglomerates, much contorted; while the Upper Silurians come in on the east of Dolfan, in the vale of the Ithon.

Some years ago, I was inclined to believe that the boulder masses of conglomerate, which lie so thick as boulders, between Dolfan and the Builth district, and which occur so frequently in the till along the river courses, were Harlech Conglomerates from North Wales. Later investigations convince me that they are conglomerates of the Lower Llandovery age, and that they are local witnesses of the enormous denundation and

erosion which have been at work over the whole of this country. Here and there, too, are boulders of slaty grits.

Slaty rocks and conglomerates, all much twisted and contorted, are seen in the gorges of the Elan river. A fine walk may be taken from Rhayader to Cwm Elan, crossing the summit of Cefn Craig-y-Foel, whose crags are composed of interstratified Llandovery slates and coarse conglomerates. The views are very beautiful from Cwm Elan. When I was at Rhayader, several years ago, the lead mines in the Clarwen were being worked, and the rubbish was poisoning the fish without a sufficient quantity of ore being extracted to pay the miners. I saw some rich specimens of ore, which (as was the case, no doubt, with some of the Dolgelly gold) may have been imported, for the occasion, to Nant-y-Car, and also some hand specimens of greenstone said to have been found at Dalrhiw. There is, I expect, a trap dyke running from the Drygan, across the hills to Cefn Craig-y-Foel, which disturbs the strata, and lead ore occurs thinly along its strike.

RADNORSHIRE, S. OF LLANBISTER.



b. Tarannon shales (pale slates). *c*. Denbigh grits, &c. *d*. Wenlock shale in its ordinary characters.

MAY HILL SANDSTONE.

(UPPER LLANDOVERY OF MURCHISON).

These strata were originally confounded with the Caradoc rocks, but, at length, their proper horizon and position were determined by the Rev. T. T. Lewis, Prof. Sedgwick, and Prof. McCoy, and their unconformability was worked out by Messrs. Aveline and Salter.

They are nowhere exposed in North Wales, although the Tarannon shales, which immediately overlie them, attain their greatest thickness in Montgomeryshire. In Shropshire, they

skirt the Longmynds in a triple division of grit, limestone, and shale, and range to Builth, Llandovery, and Llandeilo, being also developed as far south as Pembrokeshire, where they occur at St. Marloes Bay. The upper beds are brownish yellow sandstones with thin limestones often concretionary, and there are conglomeratic beds at their base in many localities. As these rocks are of very little use for building or lime burning, they are rarely quarried to much extent.

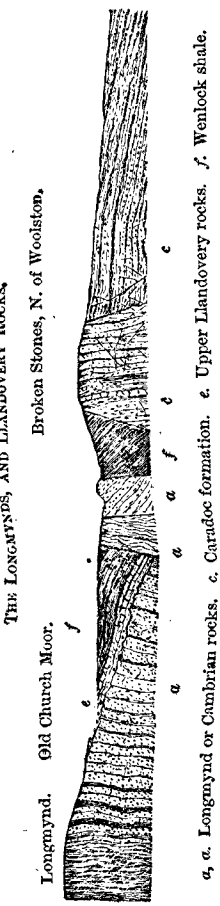
With reference to their organic remains, Pentamerus lævis, P. oblongus, Stricklandinia lens, Petraia bina, and Tentaculites annulatus, may be said to be the typical fossils.

It was as long ago as in 1850, that my friend the late Rev. T. T. Lewis accompanied me from Aymestry to the Church Stretton district, and pointed out to me the site of a small quarry near the Hollies farm, to which, twenty years before, he had also conducted Sir R. I. Murchison, who was then engaged upon his "Silurian System." Here they obtained the typical Upper Llandovery fossils, and, although Mr. Lewis always maintained the unconformability of the Hollies limestone to the underlying Horderly, or Caradoc beds, the mineralogical similarity of the strata and the close proximity of one group of rocks to the other, at the Hollies Farm, misled Murchison, eventually, with regard to their true stratigraphical position in this and in other localities.

In 1855 I once more visited this spot with Sir C. Lyell and Mr. Lewis, who again pointed out how the farmhouse was built on Caradoc sandstone full of Bala fossils, and how the true May Hill beds abutted, and rested against them in other places. I mention these facts because I believe that Mr. Lewis endeavoured to convince Sir Roderick of this unconformability, years before it was acknowledged and accepted.

When tracing out the position of the May Hill rocks, the geologist cannot do better than again take up his quarters at the Craven Arms, Stokesay, and while pursuing his investigations he must not omit to visit Stokesay Castle, a good specimen of the castellated mansion of former days. It was the abode of the Ludlow family in the reign of Edward I., for,

in 1291 Laurence de Ludlowe obtained a license to strengthen with a wall of lime and stone, and to crenellate his mansion of Stokesay. What now remains of the castle is supposed to be his work. The chimney piece of carved oak is said to be of the time of Charles II., and the remarkable gate-house of wooden framework covered with carving, is believed to belong to the Elizabethan period. Of late years, this ancient gate-house has often afforded a night's shelter to the roaming geologist, who came to investigate the intricate section of the Onny river, or knock out the fine Pentamerus Knightii from the "View Edge" which towers above the vale. In the old hall there is, or was, an admirable model of the surrounding country coloured geologically by the hands of my friend and brother geologist the Rev. J. D. La Touche, rector of the parish, and well known for his extensive knowledge of the country. No geologist should pass his door!



I do not consider the much-visited Onny section at all the place to understand the correlation of the May Hill rocks with the overlying and underlying strata. In order to comprehend their relations with the other beds in this district, it is necessary to observe how they range unconformably round the Longmynds, resting in one place against Cambrian slates, in another against Llandeilo rocks, and in another against Caradoc rocks. I have already alluded to the section in the Onny river at Cheney Longville. It is a

celebrated section, but a very difficult one to see, and here the Hollies Pentamerus beds abut against the Caradoc rocks, containing the characteristic trilobite Trinucleus caractaci, and the Tarannon shale appears under the form of purple shales, much resembling those observed in the Malvern tunnel above the May Hill (Hollies) limestone. Northwards at the Eaton brook, the Hollies limestone forms "Jacob stones," and it appears that in an old limekiln near, the walls were built of stones from beds full of Bala fossils, in which were burned "Jacob stones" full of May Hill fossils, and, as is not surprising, this conglomeration led Sir R. Murchison wrong.

The villages of Kinley, and Church Preen, N.E. of Church Stretton, are built upon sandstones and conglomerates, which lie below the Pentamerus or May Hill beds, while the door sills consist of Pentamerus limestone. Following the Caradoc strike of rocks north, to the Wrekin, we see them overlapped by the Hollies beds.

In the early days of the Geological Society, and as long ago as 1811, Mr. Arthur Aikin drew attention to the many interesting features which the mineral formations of the county of Salop presented to the geological observer, and more especially he directed attention to the Wrekin, and the Coalfield of Shropshire. Mr. Aikin treats of the trap rocks of the Wrekin, and it reads strangely nowadays to find the Wenlock shales spoken of as "die earth;" their fossil shells as "bivalves chiefly of the genus Cardium," and the trilobite Calymene blumenbachii, as the "Entomolithus paradoxus, or Dudley fossil." (Trans. Geol. Soc. Old Series p. 199). Nevertheless he appears to have recognised the position of these rocks as occurring on the flanks of the Wrekin and Caer Caradoc. They crop out on the south-eastern slope of the Wrekin, where they dip under the Wenlock shales of Buildas. Fossils may be found at Gibson's Coppice, and there are also beds of conglomerate with jasper and quartz.

Looking once more southwards we find the upper Llandovery or May Hill beds exposed at Corton, near Presteign, in Radnorshire. They underlie altered Woolhope limestone,

cropping out around Nash Hill. They are highly inclined and contain the characteristic fossils.

Again near Old Radnor they occur as thick pebbly conglomerates underlying the metamorphosed Woolhope limestone, and they are thrown off from the volcanic rocks of Old Radnor hill. The conglomerate is well exposed between Harpton Court and Stockwell. I have seen large transported boulders of this Old Radnor conglomerate on the flanks of the hills near Kington, and on eminences as high as the Kington race-course, resting on strata which belong to a far higher geological position. The peculiar position of this May Hill or Pentamerus conglomerate indicates that the seacoast of the period was along its line, as such conglomerates must be formed by shore action of the waves or by strong marine currents. Such shingle beds are not formed by deep seas.

At Pencerring, near Builth, these beds are seen to overlie unconformably the Llandeilo Flags and interstratified traps, and many typical fossils, such as Pentamerus oblongus and Petraia occur in a small quarry near the fishpond.

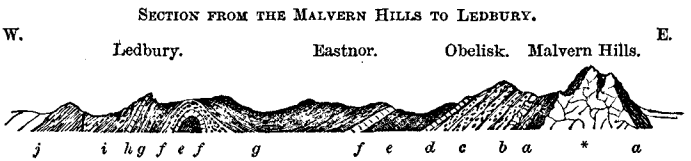
In the Llandovery district, the Upper series overlie unconformably the Lower Llandovery grits and building stones, and cap the summits of the hills of Noedd-y-grug and Cefn-y-garreg.

In the valley of Woolhope they rise into the dome of Haughwood; but there are no sections, and the beds only crop out here and there, as thin brown sandy deposits.

UPPER LLANDOVERY ROCKS OF THE MALVERN HILLS.

In his paper "On the Mineralogy of the Malvern Hills" (Transactions of Geological Soc. Vol I. 1811) Mr. Leonard Horner evidently recognised the occurrence of the May Hill rocks among the stratified deposits on the western side of the Malverns, and he speaks of them as "compact quartoze sandstones" containing impressions of fossils, while he notices a peculiar feature in the Pentamerus sandstones, viz., the tendency to "break into rhomboidal fragments" and this is the characteristic tendency of these beds. In the Malvern and

Abberley districts, Professor Phillips calculated that these strata assume a thickness of 600 feet; and with regard to the Malvern Hills, it is worthy of remark that fragments and uplifted outliers have been found clinging, as it were, to the axis of the range, against which they must have been deposited as



This woodcut, slightly modified from a coloured section in the "Silurian System" (pl. 36, f. 8), explains the general order and the undulations on the west side of the Malvern Hills, in the parallel of Midsummer Hill, Eastnor Park, and Ledbury. The eruptive rocks, *, of the Malvern ridge are associated with and flanked by crystalline oilstone, schists, and gneissic rocks, *a*. To the west these are followed by the Holly-bush Sandstone and the Black Schists with Olenus, *b*. The Upper Llandovery Sandstone and Conglomerate are marked by *c*; their higher portion dips down from the Obelisk Hill of Eastnor, and passes under the Woolhope, or Lower Wenlock limestone, *d*. The latter is followed by the Wenlock shale, *e*, and the Wenlock limestone, *f*; which last, bending under the Lower Ludlow, *g*, reappears in a dome that throws off towards Ledbury the whole of the Ludlow formation, *h i*, after a flexure in Wellington Heath, under the Old Red Sandstone, *j*.

a submarine shingle beach, the elevatory movements which affected the Malvern axis having carried up the May Hill and Pentamerus beds on its flanks. Such is the case at the Pass of the Wind's Point, where, above Mr. Johnson's residence, Mr. Dyson found them resting uncomformably upon the old stratified and contorted gneiss. At the Holly Bush Hill, Dr. Holl found them resting against, and overlapping, the black shales; and again at the "Ragged stone," where I myself found their fossiliferous sandstones overlapping the green Holly Bush sandstones of the eastern quarry, on the Ledbury high road.

When engaged in investigating the sections in the Malvern tunnel, on the Worcester and Hereford railway, in 1861, I had the advantage of seeing and measuring foot by foot, an excellent section of the grey and purple slates which intervene between the Woolhope limestone, and the Pentamerus, or May Hill sandstones and purple mudstones. The conclusions I arrived at, were, that in the Malvern district the May Hill strata lay at

the base of all the Upper Silurian rocks. It was also evident that a considerable portion of the Malvern range must have lain beneath the seas of this Upper Llandovéry period during the deposition of the May Hill strata, and their marine shells, for we found, almost in the centre of the axis, two thin bands of May Hill, or Upper Llandovery, limestone with strata of marl shales two feet thick, lying in a fissure of the gneiss. In these shales the Rev. Reginald Hill, Hon. Secretary of the Malvern Field Club, was the first to find specimens of the Pentameri so characteristic of these strata. We found evidences of great pressure and crushing, but no signs of any metamorphism or alteration by volcanic agency. The sedimentary deposits were evidently laid down in a fissure in the syenitic axis, during that far distant epoch, when the waves of the Upper Llandovery seas washed above the syenitic range of the Malvern gneiss, and when the hills themselves must have been a submarine ridge, of which the rocky axis, even in that far remote period, was as consolidated and mineralised as at present.

An interesting point for the lover of physical geology occurs near the pass known as the Gullet, east of the obelisk in Eastnor Park, and near a keeper's lodge. Here, by following the stream down the Fair Oaks vale, beds of Llandovery rock with fossils may be seen caught up in the hollows of the syenitic gneiss down which the streamlet flows, and from their position in this hollow, as well as on the eastern flank of the Swinyard Hill, it is evident that they extended on the eastern as well as on the western sides of the Malvern axis.

The May Hill beds strike north in a kind of escarpment, passing above Bronsil Castle, and below the obelisk in Eastnor Park, up to the northern end of Midsummer Hill. In the "Silurian pass" of Phillips, they rest, as in the Malvern tunnel, directly against the old syenitic rocks. In Dr. Grindrod's Museum at Townshend House, Great Malvern, there are a number of plant like fossils which were obtained from the shales on the western side of the Malvern tunnel. They are similar to the specimen found by my friend Mr. Lees, the President of

the Malvern Club, and which was figured by Sir R. Murchison in "Siluria" (2nd. ed. p. 106). Mr. Salter informed me that he thought these branched, plant like bodies would prove eventually to be graptoloid animals, and not seaweeds or land plants. From the same beds Dr. Grindrod has large slabs of shale covered with the casts of that fine shell Stricklandinia lens (Atrypa lens of Sil. System). Perhaps the best way of collecting some of the characteristic fossils of this group of rocks, is to commence at an escarpment of rock exposed near the summit of the Gullet Pass. An hour's hammering at this little section will supply the geologist with Lingula parallela, and Lingula curta, which in these beds have a peculiar metallic look, and sometimes a purple tinge. Ctenodonta Eastnori (Arca East. Sil. System) is a bivalve shell, allied to the Arcadæ, and Nuculæ, and in some specimens found at the Gullet Pass, the teeth of the hinge are well marked.

Following the path towards Bronsil westward, we come upon other hollows where a little rock has been excavated below the obelisk. In the first of these small rock sections the geologist may find besides Lingula, casts of a large Pterinea, a bivalve shell allied to the Aviculidæ or wing shells, and of which several species occur in the May Hill strata. In the upper quarry above the pathway, Mr. John Burrow of Malvern found the swimming foot of a highly organised crustacean, Pterygotus problematicus. The specimen is figured by Sir Wm. Jardine in his "Memoirs of Hugh Strickland" (p. 357). The Pterygoti are believed to have been allied to the Limulus, or King Crab, of the tropical seas. These living Crustacea sometimes attain the length of two feet, and in the regions they inhabit they are used for feeding pigs, the natives also employing the horny style at the extremity of the body for pointing their arrows. Remains of crustaceans of immense size have been found in the Upper Silurian, and Old Red Sandstone strata, but this specimen of the Pterygotus occurring in beds so ancient as the Upper Llandovery rocks of Eastnor, is at present unique.

At Howler's Heath, on the south-west flank of the Malverns,

the Upper Llandovery beds are exposed in small quarries of purple and grey grits, dipping round the hill, as if from some trappoid masses underneath. These purple grits are overlaid by thin brown sandstones which crop out at the surface, in slabs used for wall stones, and they contain Pentameri, Stricklandinia lens, and numerous casts of Petraia bina. The purple beds below them have furnished a very large form of Lingula (L. crumena). The only specimens I have ever seen are in the collections of Dr. Holl, Mr. Lyell, and in the Museum of Practical Geology in Jermyn Street. These purple beds are as a rule very unfossilliferous, but the finest specimens of Stricklandinia lens I ever obtained were found in these purple sandstones, when making an expedition with Mr. Alex. Agassiz to Howler's Heath, in hopes of procuring the shell. It occurs abundantly in the equivalent strata, the Clinton Group, in America. Howler's Heath is particularly barren as regards wild flowers, but it is especially rich in fungi of various species, so also are the woods on the same beds on May Hill. In autumn the Heath is the resort of those who search for rare forms of Agarics, and more especially for the edible species, such as Cantharellus cibarius, Hydnum repandum, Agaricus procerus, &c. After the dry summers of 1869 and 1870, the woods of Howler's Heath furnished numerous forms of fungi, when it was vain to look for them elsewhere.

The Lickey is a range of hills, north of the town of Bromsgrove, where a few years ago the summit was a great waste covered with the heather (Calluna vulgaris), the gorse (Ulex Europæus), and the cranberry (Vaccinium Oxycoccus). The latter plant still grows on portions of the hill-side, but enclosures and cultivation have left little that can now be termed "wild" on the Lickey, and turnips, and clover now flourish where a hundred years ago the black cock and grouse were not uncommon. Dr. Buckland first made the Lickey quartz rock famous, through noticing the quantity of wreck derived from the hill masses, which he found dispersed over large tracts of country in the shape of gravel and débris. From the abundance of these rounded pebbles of "granular

quartz rock," which he observed at Cannock Chace in Staffordshire, and at Coleshill, east of Birmingham, at Shipston, and Moreton in the Marsh, and even in the vale of Evenlode, by Charlbury, this celebrated geologist drew conclusions with respect to denudation, and the distribution of superficial gravel beds, which he referred to the Deluge, and its subsiding waters. Years have passed away, and the Deluge, and "Diluvian wave" theories, have given way to later investigations and discoveries, but the Lickey quartz drifts will ever have a high interest to the physical geologist, whether we look upon them as deposited by the waves of an iceberg traversed sea strait, and when the vales of Worcester, and Gloucester, were submerged beneath the waves of the Malvern straits; or whether we see them rolled into the low level drifts of an ancient Severn or Avon, and mingled with the bones of the hyæna, the rhinoceros, the hippopotamus, and the bear. My friend Mr. Lucy of Gloucester has published, in the Transactions of the Cotteswold Field Club, the most exhaustive paper ever penned, upon the subject of these northern drifts, and no one who has studied them, as he has done, can doubt but that in pre-glacial times, the quartz rocks of the Bromsgrove Lickey, had a far greater extension, and that in the times of the Severn straits, a most extensive denudation took place, and scattered their débris far and wide over the country.

The best route for the examination of the Lickey, is to go from Holly Hill to Kendal End, where a ridge of quartzose rock is here and there exposed. This ridge is the Lickey quartzite, or the metamorphosed sandstone, which in 1834, was determined by Sir R. Murchison to be of the same age as the May Hill sandstone, then considered by him to be of Caradoc age. It was at the northern extremity of Snead's Heath, that he found the Pentamerus oblongus, which we now know to be so characteristic a fossil of the May Hill, and Upper Llandovery deposits, and since then the acquisition of many specimens, some of which are from the metamorphosed quartzites, settles the point that the quartz rock of the Lickey

is altered May Hill sandstone. There is a large quarry between Rednall, and Rubery, where the strata are nearly horizontal; it is worthy of observation as showing the elevation of the beds.

The fact that volcanic materials have been injected into the Lickey rocks may be seen between Kendal End, and Barnt Green, where a dyke of trap penetrates the rocks by means of a fissure; and there is little doubt that the long elevated tract called "The Ridgeway," which extends to the south-east, owes its elevation to this trappean eruption. It is the western watershed of the Arrow brook.

Thus, at Rubery Hill, Colmers, and Kendal End, we have masses of May Hill rock, for the most part much metamorphosed, forced up through the Coal-bearing strata, and the overlying Triassic sandstones of the surrounding country, by earthquake action accompanied by volcanic infiltration. It is a most instructive district, and to the competent geologist well worthy of repeated visits. The New Red conglomerates of the Trias contain Lickey quartz pebbles, showing that extensive denudation took place in Triassic times.

May Hill, which gives its name to these Upper Llandovery rocks, is a great prolongation of the axis of Silurian strata from Woolhope to Purton, and Tortworth, across the Severn into Gloucestershire. It is supposed by some to take its name from Maia, the mother of Mercury, who we now behold in the heavens as one of the Pleiades; while the less antiquarian mind attributes the name to the fact, that on May-day in times gone by, the good folk of Gloucester danced upon the green, among, and around, the firs that are planted on its summit. Nowhere in this part of England is there a nobler view! To the north rise the ancient Malverns, the Silurian rocks of Ledbury and Woolhope clothed with wood, and to the north-westward peep out in the distance the Welsh mountains of Old Red Sandstone, with here and there an outlier of Carboniferous rocks, telling of the history of denudation between points so distant as the Pen Cerrig Calch, near Crickhowell, and the Clee Hills in Shropshire. Westward is the Forest of Dean, with its

Old Red base, and all the Carboniferous series on its summit; and eastward is the Severn wandering by the old Norman cities of Worcester, Tewkesbury, and Gloucester, among the battle fields of centuries, by ancient cathedrals, abbeys, and churches, until it expands into its fine estuary; and far away to the south we see its glistening waters bordered by the Cotteswold, the Mendip, and the Quantock Hills.

The Llandovery, or May Hill rocks, throw off newer Upper Silurian beds on each side. On one side they are flanked by the Passage beds, Old Red, Coal measures, Permian conglomerates, and New Red Sandstone, to which we shall allude elsewhere. But the lowest exposed strata are the fossiliferous Upper Llandovery rocks, which rise to the summit of the hill and strike on their south-eastern prolongation to Huntley Hill. The lower beds of these strata are greenish grit, and conglomerates of grey and purple colours, much faulted and sometimes nearly vertical, and the upper are grey shales, and thin bedded sandstones, with bands of fossils, which, as is generally the case in these deposits, appear as casts. The geologist who knows these rocks in the Malvern neighbourhood, may bring his experience to bear upon the rocks here, although we do not recommend May Hill as a locality for the stranger to examine the strata which bear its name. The Malverns afford far better ground for observation. The best places in the district to see the May Hill rocks proper, are Huntley Hill west of Huntley, and the south-east of May Hill near Huntley, with the small quarries at the summit near the firs. The oldest rock at May Hill, is seen on the turnpike road from Gloucester to Ross, near the village of Huntley. It stands out from the Triassic plain, a dark greenish rock with veins of quartz, and it is certainly more or less metamorphosed. Sir R. Murchison thought it might be of Cambrian age. After examining it, in company with Dr. Holl, and Mr. Salter, we came to the conclusion that it must be referred to the lower beds of the May Hill group. It underlies the Pentamerus beds, and the overlying group of rocks which were deposited on and around its flanks. Mr. Turner, formerly of Pauntley, found Lingula parallela in the

green grits of this quarry. The strata are strangely faulted, indeed the Silurians are here set in a frame of faults, with Old and New Red all round. There is probably much more geology beneath the dome of May Hill than we are destined to see from its surface. In all likelihood, a tunnel through the centre of the hill would reveal an axis, consisting of rocks belonging to a far older period than that of the Llandovery beds; it may be of Malvern gneiss, or some hardened trap of Laurentian or Cambrian date. The same north and south anticlinal which rises into the hills of May Hill and Huntley, is prolonged to the south, under Newnham; crosses the Severn at Pyrton Passage, and again rises at Tortworth, where the May Hill beds are exposed at Long's and Sheay's quarries, Charfield Green, and Damory Bridge. They are here traversed and altered by trap dykes.

UPPER LLANDOVERY ROCKS IN SOUTH PEMBROKESHIRE.

These May Hill and Upper Llandovery rocks, which are so discordant to the underlying Lower Silurians wherever seen in junction, appear in South Pembrokeshire, where I examined them some years ago in company with Sir William Guise. They appear in the extraordinary upcast of Silurian rocks in Marloes Bay, and Pentameri occur in nearly vertical strata. There is a good section taking the island of Gateholm, consisting of Old Red Sandstone, and the detached mass of Old Red on the mainland. This mass of Old Red is faulted against May Hill beds and Wenlock shales, or Tarannon shales.

At Marloes Bay and Wooltack Park, the Pentamerus beds are jammed up, tilted, and broken, together with Caradoc strata with their fossils, but it is impossible to distinguish the one series of strata from the other. As a local geologist informed me, "They are slates just like one another, both faulted and tilted together, and both affected by that same confounding cleavage;" and so we found them!

The mineralogical character of the May Hill beds is much changed in this district. North of Milford, they appear

between the Old Red rocks of Steynton and the trap of Johnston. Stricklandinia lens and other typical fossils occur in these beds, which are also charged with casts of encrinital stems.

TARANNON SHALES.

These shales may be studied at Tarannon, a peculiar district in Montgomeryshire. The hill and river of Tarannon lie to the north-east of Blaen Hafren, the source of the Severn, and the Tarannon itself rises in a mountain outlier of Denbighshire grits, between Llanbrynmair, and Llanidloes, and west of New Town. These shales form the summit of the Middle Silurians.

They are of a peculiar pale grey colour, hardening sometimes into pale slates interstratified with purple and greyish-green shales. Between Aran Mowddwy and the south side of the Berwyns, they rest unconformably upon Lower Llandovery grits and sandstones, and are overlaid conformably by the Denbighshire grits. They may be seen near the mouth of the Conway, and may be traced up to Melynllyn, between the town of Conway and Llanrwst, on the great line of fault along which the river flows. The Lower Llandovery strata are not exposed in the district between Bala and Conway, being probably overlapped by these beds and by the Denbighshire grits.

There are also sections of these uninteresting beds, exposed on the banks of the Wye, near Newbridge, between Builth and Rhayadr, above the confluence of the river Ithon. They rest on Caradoc and Lower Llandovery strata.

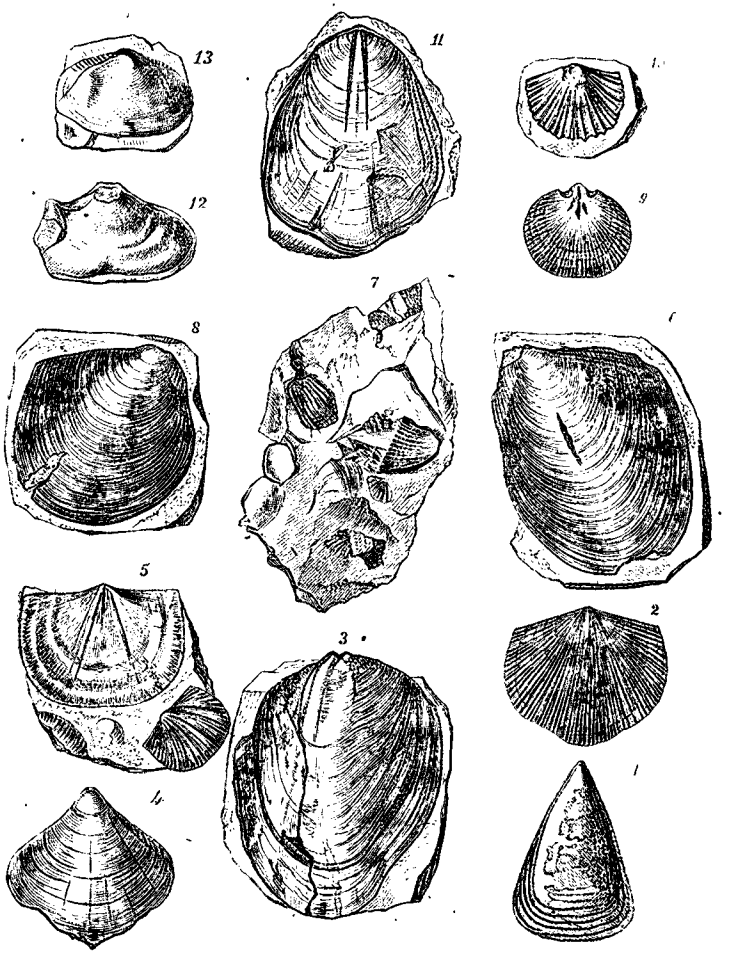
Sir R. Murchison gives sections, in his last edition of "Siluria," showing the position of the Tarannon shales in several localities, and in each instance their position is the same as that occupied by the Woolhope shales in the Malvern tunnel, viz., at the base of the Wenlock beds and conformable to them. In fact, to the west, the Tarannon shales lie at the base of the Wenlock and Denbigh rocks (as do the Woolhope shales to the east) all the way from Newbridge to Conway.

Llandrindrod, well known throughout South Wales for its

mineral springs, affords good head quarters for the geologist studying the Tarannon shales. The great volcanic district of Radnorshire extends from Llandegley, and Llanbadarnfawr on the north, to Builth, on the south-west; and Lower, and Upper Silurian rocks afford manifold investigations in their intricate folds, and displacements. Owing to faulting in the Builth country, the Tarannon Shales, which occur near Newbridge, are cut out altogether at Pencerrig, north of Builth, in the section where the May Hill beds are seen resting against trap, interstratified with Llandeilo beds. Very striking, in this country, is the effect produced by intrusive rocks, and hard lavas, protecting marine sediments from denudation, especially when the sedimentary matter is interstratified with volcanic outpour of lava. Many of the hills in this district, such as Llandegley, and Cefn Llys, consist of stratified traps, alternating with sedimentary rocks full of fossils of Lower Silurian age. At Cefn Llys, on the hill rising above the river Ithon, formerly stood a castle, known as Castell Glyn Ithon. It was erected in 1242, and Leland tells us that it was demolished in his time, during the reign of Henry VIII.

The situation of Cefn Llys church is remarked upon by Sir Roderick Murchison as singularly beautiful in its well wooded and deep valley, "where the Ithon, emerging from this volcanised region through a narrow gorge of trap rocks, passes between cliffs of about forty feet in height, from the sides of which a single plank serves as a bridge over the stream." (Sil. Syst. p. 329.) Many years ago, when visiting an old friend, now dead and gone, in the neighbourhood of Builth, I crossed this country with my hammer, and a light fishing rod, with sketches of Murchison's sections in my note book. A boy of the country accompanied me, and hearing that the Ithon was in first-rate order, I gave up the hammer for the rod. At Cefn Llys, however, I occasionally put into the fishing basket, carried by the lad, pieces of stone and gravel, from the bed of the river, to examine on my return to Llandrindrod. The fish ran well at the minnow, and I remember finding my youthful guide in tears, at having to carry "a big basket cram full of

PLATE III.



1. Lingula crumena.
2. Strophomena grandis.
3. Stricklandinia lens.
4. Pentamerus lævis.
5. Orthis alternata. Sow.
6. Modiolopsis vel Modiola orbicularis.
7. Petraia bina.
8. Modiolopsis vel Modiola orbicularis.
9. Atrypa reticularis.
10. Ortis calligramma.
11. Pentamerus oblongus.
12. Ctenodonta subæqualis. M'Coy.
13. Ctenodonta Eastnori. Sow.

[*Page* 151.

fishes weighted down by stones to spite him, he supposed, and he didn't know why," at least, such was my friend's translation of his diction.

In the Llandovery country, Mr. Salter informed me that the Tarannon shales occur in the Noedd-y-grug, and Cefn-y-garreg hills, and are conformable to the May Hill, or Pentamerus rocks, on which they rest. They strike in a south-westerly direction to Pen-y-lan.

On referring to my paper on the Malvern and Ledbury tunnel in the "Proceedings of the Geological Society" (January 9, 1861), I find that there is a thickness of nearly 350 feet of grey and purple shales, intervening between the Pentamerus limestones, and May Hill beds, and the Woolhope limestone. These I designated as "Woolhope shales" and I believe them to be the equivalents, in the Malvern district, of the Tarannon shales, or Pale slates, of Professor Sedgwick.

ORGANIC REMAINS OF THE MIDDLE SILURIAN ROCKS.

The genus Petraia, belonging to the group of cup corals, is very typical of the Llandovery rocks; and when the geologist finds the common species, Petraia subduplicata, in abundance, he may be sure that he is working among the Lower Llandovery beds. The larger species Petraia elongata occurs more frequently in the May Hill group, as does also P. bina, which is found in the Woolhope limestone, and ranges into the Wenlock rocks. It is constantly met with at May Hill.

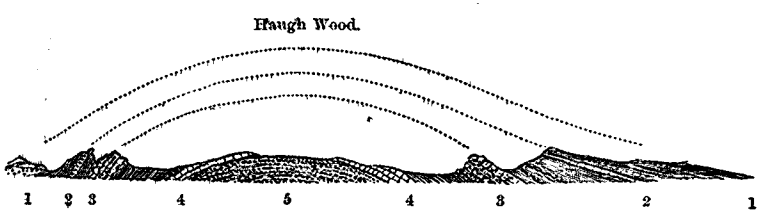
Among the Brachiopoda, five species of Pentameri are characteristic of this zone of rocks. Stricklandinia lens and P. undatus are found in the Lower Llandovery strata, and Stricklandia lens, P. oblongus, P. liratus, and P. globosus, abound in the May Hill rocks; the two latter fossils are however rare in the Lower Llandovery deposits. Atrypa crassa is the typical species of the lower strata, A. hemispherica occurring in the Upper series only. Atrypa marginalis and A. reticularis are very abundant in both groups of rocks in some localities.

Rhynconella decemplicata is typical of the May Hill series.

Orthides which occur in the Lower Silurians, are met with in these Middle Silurian rocks.

There are no Trilobites which can be said to be strictly characteristic of this zone, except the Illænus Thomsoni of Salter. Three or four Lower Silurian species range upwards into the May Hill beds, but the forms we meet with chiefly are Upper Silurian species; among them is the well known Calymene Blumenbachii, which passes from the Caradoc strata into the Upper Ludlow shales. We have already mentioned that we find the first evidence of the appearance of those peculiar crustacea, the Pterygoti, in the May Hill rocks of Eastnor, on the west side of the Malvern Hills. A portion merely of one of the swimming feet of this animal was discovered. The Pterygotus of the Upper Silurian rocks is supposed to have attained a length of five or six feet, thus far surpassing the largest living lobster or crab in size.

SECTION ACROSS THE VALLEY OF WOOLHOPE.



5. Up. Llandovery. 4. Woolhope beds. 3. Wenlock limestone. 2. Aymestry rock. 1. Base of Old Red.

CHAPTER VI.

UPPER SILURIAN ROCKS.

Denbighshire Grits—Denbigh Castle—Striations on Carnedd Davydd and Carnedd Llewelyn—Legend of St. Winefrede—Bettws-y-Coed—Mallwyd, Scenery of—Woolhope Limestone—Old and New Radnor—Stanner Rocks, Rare Plants on the—Dome of Haughwood—Earthquake Action and Denudation—Drift Gravels—Cerig-y-Druidion—Ruthin, Antiquities of—Dinas Bran, Eagles at—Wenlock Edge, View from—Coral Reefs—Buildwas Abbey—Landslip near Leighton—Wenlock Abbey—Milburga, Lady Abbess—Wigmore Castle, Ruins of—Limestone Quarries at Dormington—Crinoidea—Ludlow Rocks—Scaphaspis Ludensis—Offa's Dyke—Bone Beds—Milton at Ludlow Castle—Grayling in the Teme—Aymestry Limestone—Ledbury—Passage Beds—Exposition of in Ledbury Tunnel—Lycopodites in Bodenham Passage Beds—Usk—Organic Remains of the Upper Silurian Rocks.

		Typical Fossils.
7. Ledbury Shales or Passage Beds.	*Fish.*	Auchenaspsis, Cephalapsis, Onchus, Plectrodus, Pteraspis, Scaphaspis.
6. Downton Beds and Tilestones.	*Crustacea.*	Pterygotus, Eurypterus, Beyrichia.
	Shells.	Lingula, Platychisma, and a Lituite, also Murchisonia.
5. Upper Ludlow Rocks.	*Fish.*	Pteraspis, Scaphaspis.
	Crustacea.	Calymene Blumenbachii, Homalonotus Knightii, Illænus Barriensis, Phacops caudatus.
4. Aymestry Limestone.	*Shells.*	Pentamerus Knightii, and P. Galeatus. Orthonota several species. Murchisonia, Cardiolæ, Phragmoceras.
3. Lower Ludlow Rocks.		Graptolites. Starfish. Oldest known fish, Scaphaspis ludensis.

			Typical Fossils.
2. Upper Wenlock.	Wenlock Limestone. Wenlock Shale.	*Fish.*	None yet discovered.
		Crustacea.	Phacops caudatus, Calymene Blumenbachii and C. Downingiæ, Illænus Barriensis, Encrinurus variolaris, Sphærexochus, Lichas.
		Shells.	Atrypa reticularis, Discina Forbesii, Strophomena depressa, and Euglypha cardiola, Euomphalus discors, and Euomphalus funatus, Murchisonia, Bellerophon Wenlockensis, Conularia Sowerbyi, Lituites Biddulphii, Orthoceratites of several species.
1. Lower Wenlock.	Woolhope Limestone. Denbighshire Grits.		Many beautiful Encrinites, with Echino-dermata, and Annelids such as Tentaculites.

In North Wales the Tarannon shales are succeeded by a thick series of grits, shales, and sandstones, named Denbigh grits by Mr. Bowman, and Professor Sedgwick, and believed by them to be the base of the Upper Silurian rocks of North Wales. We learn from the investigations of the officers of the Geological Survey, that the Denbighshire grits are Lower Wenlock strata, changed and altered as regards their lithographical constituents, but containing Wenlock fossils. They are thick, sandy, representatives of the Woolhope strata.

The geologist, acquainted only with the Woolhope limestones, and shales, as they occur in the districts of Malvern, Woolhope, May Hill, Corton, and Radnor, is accustomed to search for them at the base of inconsiderable hills, and to see them resting against the May Hill Pentamerus beds, in a very masked position. He is therefore unprepared for the complete change in mineralogical structure assumed by these beds in North, and South Wales, when they become the coarse, thick-bedded, Denbighshire grits, and rise into mountain ranges. The general character of the country occupied by the Denbighshire

grits is particularly barren and bleak, but it is an interesting district to the lover of physical geology, as it affords him good opportunities of observing how vast masses of strata have been removed by subaerial denudation, and great valleys have been cut out in horizontal mountain plains by glacier action, melting snow, running water, and drainage waste. On ascending the hills we find a series of outliers of what must have once been a great table land; while it is evident from the position of the underlying, contorted, rocks, that they were contorted and elevated before their upper surfaces were planed down, and before the denudation of the valleys took place.

Between Llanrwst and Denbigh stretches a bare and wild district remarkable for the peculiar scenery of the Vale of Aled, and the Hiraethrog hills; this bleak chain consists of Denbighshire rocks, and divides the watersheds of the Dee, and the Elwy. The Alwen, the Aled, and the Elwy all rise in the Hiraethrog mountains, the Alwen flows into the Dee, and the two latter into the Clwyd.

Denbigh itself stands on a hill of Mountain limestone, the Silurian rocks having been greatly denuded, before the Carboniferous limestone which now underlies the vale of the Clwyd was deposited in the synclinal bend, of which the great Moel Fammau is the most elevated eastern edge; while to the west, is the strange old table land cut into a network of valleys, which renders this part of Wales so difficult of access, that it is traversed by few save the wandering geologist or angler. Fossils may be found about Llansannon by following the route up the Aled river to the waterfalls. Orthoceratites are the most common here, and the Leptæna lata of the "Silurian System," a characteristic fossil of the Upper Ludlow shales, in Siluria proper, has been met with in this district, in sandy grits, with corals and encrinites. In the river drift below the first waterfall Llyn-yr-Ogo, are trap pebbles, derived from some dyke in the hills above.

The district of the Denbighshire grits was comprised at the period of the Roman invasion, in that part of Cambria occupied by the Ordovices who peopled the desolate wastes between the

vale of Clwyd and the Conway. It is said that they had extended their dominions from Shropshire and Cheshire to these wild hills of Wales. We find that mention is made in Leland's "Itinerary," (vol. v. page 59) of the "Rounde Table" in the parish of Llansannon. It is a British amphitheatre known as Bwedd Arthur, Arthur's round table, and Leland says "it is in the side of a strong hille wher ther be 24 holes or places in a roundel for men to sit in, but sum lesse and some bigge cutte oute of the mayne rok by mannes hand."

The Castle of Denbigh is said by antiquaries to stand on the site of an ancient British fort, which on the fall of Llewelyn, was bestowed on Henry Lacy, Earl of Lincoln, by Edward I., and Leland says the earl was a great lord marcher in Ewisland and that "afore his tyme I cannot lerne that there was other town or castelle." Nevertheless, from the name Dinbech (a hill fortress) and the still older appellation of Castell Cled fryn yn Rhos, there is little doubt that this hill was a fortress when surrendered to Edward. Leland saw it himself; and says that "The castelle is a very large thing and hath many toures yn it. But the body of the worke was never finishid. The Gatehouse is a mervelus strong and grate peace of work, but the fastigia of it were never finished. Sum say that the Erle of Lincolne's son felle into castelle welle and ther dyed, whereupon he never passed to finish the castelle." ("Itinerary," vol. v. p. 57).

Churchyard saw it after Leland's time (in about the year 1560), and he gives a very quaint description of Denbigh, "garland of our daies." Writing of this fortress, he says:—

> "This castle stands, on top of rocke most hye,
> A mighty cragge, as hard as flint or steele,
> A massie moint, whose stones so deepe doth lye
> That no device may well the bottom feele.
> The rock discends, beneath the auncient towne,
> About the which a stately wall goes downe,
> With buyldings great and posternes to the same,
> That goes through rocke, to give it greatn fame."

It was, however blasted with gunpowder in the days of Charles II., and little is now left to enable the antiquary to

restore, even in imagination, "the diverse wardes and diverse portcoliciss" of Henry VIII.'s time; or "the strength of state" "with dubble walles full thicke" of which Churchyard wrote that

> "Man might say
> The work thereof would last till judgement day."

The fragment of the gateway and the relics of walls, and ramparts, contrast powerfully with the descriptions of the old historian and poet, who little deemed that the "castelle," so fair and strong in their eyes, should be shattered into ruins before even a century should have passed away.

In the western part of Denbighshire, lies the small town of Llanrwst, which is surrounded by scenery of so varied a character, dense woods, fine hills, and the winding river Conway, as to draw from Burke the opinion that "it was the most charming spot he had seen in Wales." A remarkable fault runs along the line of the Conway from a little to the south of Bettws-y-Coed to Llanbedr; the right bank of the river is occupied by the Denbighshire grits, while Caradoc rocks range along the left bank.

Denbighshire grit fossils may be obtained at Plasmadoc, where Calymene Blumenbachii, Phacops caudatus, and Atrypa reticularis, with other Wenlock forms occur; also at Marchlyn Mawr, three and a half miles south of Conway; while we may gather Caradoc fossils by crossing the river to Trefriw.

Excursions may be made to the hill regions of Carnedd Davydd, and Carnedd Llewelyn, with their dark rock recesses formerly filled with ice and snow, and striations on their higher flanks which Prof. Ramsay believes may have been produced by the grinding of icebergs, during the submersion of the country, when the shell-bearing drifts were deposited on Moel Tryfaen, the flanks of Penmaenmawr and the vale of the Llugwy. On the east side of Carnedd Llewelyn is a glacial lake, surrounded by moraine matter borne from the summit of the mountain above, by the ice slope which deposited it. On the summit of the hill is a camp, said to have been occupied

by Llewelyn ap Jorwerth, the contemporary of Giraldus Cambrensis, and the husband of Joan, daughter of King John of England. Llewelyn was buried at Conway Abbey, but his remains were afterwards transferred to Maenant Abbey, and on the dissolution of this monastery they were carried to Llanrwst, where they are now said to rest in a large stone coffin.

On a long summer's day, a walk of about twenty miles may be taken through a country of the most romantic character, from Llanrwst to Abergele. Wenlock fossils may be found in small quarries here and there along the road. In passing through the village of Gwytherin, it may interest the lover of legends, to know that the precious remains of St. Winefrede were buried here in the church, after her second death, the saint having retired to this secluded spot for devotional purposes. It appears that her bones were removed to the Benedictine house at Shrewsbury, in the reign of Henry I.

Again, the district between Cerrig-y-Druidion and Llyn Alwen, a lake about six miles north of Pentrevoelas, in which the Alwen takes its rise, is characteristic of the Denbighshire grits. Two miles farther north, the river Aled has its source in Llyn Aled, and good bog plants grow around both these lakes. Fossils also have been found near Llyn Aled. Bettws-y-Coed is situated amidst lovely scenery, at the meeting of the waters of the Llugwy, and the Conway. It is the best point from whence to explore the mountain valleys of the Machno and the Lledr. Above Bettws-y-Coed the Conway runs through a rocky ravine, where some years ago I witnessed a most exciting otter chase. I shall not easily forget the romantic scenery, the dash of the hounds, the boisterous men, and the rushing waters. The geologist will find good Caradoc fossils in the Bala beds of Bettws-y-Coed. They furnish the beautiful Crinoid, Glyptocrinus basalis, the Trilobite, Homalonotus bisulcatus, with Orthis calligramma, O. crispa, and Orthoceras vagans. Crossing to Pentrevoelas, we come upon Denbighshire grits with Wenlock fossils. The Denbighshire sandstones of this district abut against the Caradoc strata, and

it seems as if the Tarannon shales, which occur lower down near Llanrwst, were cut out by a fault.

West of Pentrevoelas is Coch Castell, where Camden describes a stone as standing in his time, and which bore an inscription partly in Latin and partly in Welsh, and supposed to be erected over a Prince Llewelyn. The letters are now illegible, but there are the remains of an earthwork; and a cromlech was opened some years ago at Capel Garmon, opposite to Bettws-y-Coed, which contained human remains. Capel Garmon is on Caradoc strata, and the Denbighshire beds here form a kind of peninsula, running out against the Bala beds southward to Garnbris.

The Upper Silurian strata are denuded over a considerable district to the south of Cerrig-y-Druidion, and Corwen; but a narrow strip of Denbighshire rocks runs southwards to Newtown, and by the village of Mallwyd to the north of Builth in Radnorshire. The relations of the Denbighshire rocks with the underlying strata may be traced in the neighbourhood of Mallwyd; thus at Cefn Coch, the rocks are Caradoc strata, which, east of Aran Mowddwy are overlaid by the felspathic grits and slates of the Lower Llandovery beds, and these again are overlaid by the Tarannon shales, and the Denbighshire sandstones.

Mallwyd is "beautiful exceedingly." The scenery, whichever way the eye turns, is "prodigiously fine." "The mountains here form a grand natural amphitheatre having sylvan sides, amidst which peeps here and there a whitewashed cottage. Camlin rises immediately with rude grandeur on the right, and the conical Aran lifts its resplendent head to the left." * Nor is this description overdrawn. The yew-trees in the churchyard are remarkable for their unusual size, and the whole neighbourhood is celebrated for both its geological and botanical associations.

On the north side of the Berwyn Hills, the Denbighshire grits become more like the shales of the Wenlock series. In Radnorshire they may be seen north of Llanddewi-ystraed-enny, while near Llanbister they rise into the hills amongst which the river Ithon has its source.

* Evans's Merionethshire.

Llanddewi-ystraed-enny is a place famous for its ancient entrenchments. Between Llanbister and Newtown lies Cwm-hir Abbey, of which Leland says "The first foundation was made by Cadwathelan ap Madok for 60 monkes. No chirch in Wales is seene of such length as the foundation of walles ther begon doth shew." "Al the howse was spoiled and defaced by Owen Glindwr."* The "Monasticon" assigns it the date of 1143. It appears that it was to this abbey Cwm-hir, and not to Cymmer Abbey in Merionethshire, that Henry II. marched his army to attack Llewelyn ap Jorwerth.

WOOLHOPE LIMESTONE.

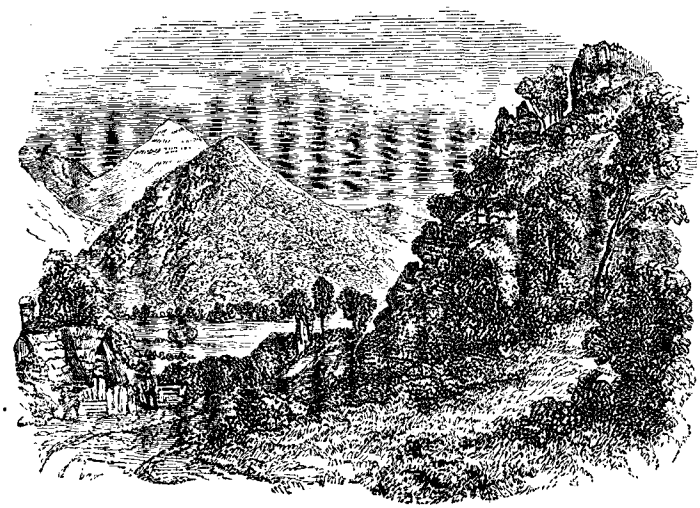
The rocks belonging to this division of the Upper Silurian series, are argillaceous representatives on the east, of the sandy Denbighshire grits on the west. The Woolhope limestone is a well defined group of rocks occurring at Corton near Presteign, Radnor, Woolhope, Malvern, and May Hill, and also at Barr in Staffordshire. This thick bedded limestone is hardly recognisable in the Wenlock district, its place being occupied by a band of nodular and concretionary shales which lies between them and the May Hill (Pentamerus) beds. The Woolhope limestone occurs at Corton, and in the quarries of Nash Scar, in a subcrystalline and partially metamorphosed state; and as long ago as in 1850, I was enabled to determine its proper place in the geological sequence of strata, from its position with respect to the Upper Llandovery beds, and from the abundance of the Barr trilobite Illænus (Barriensis) it contained; and specimens of which are certainly more numerous in the Lower Wenlock series, than in the rocks overlying them.†

Near Old Radnor, the Woolhope limestone is elevated to the surface by trap rocks, near which its stratification is almost obliterated. Towards the west, the limestone shows stratification, and rests against the May Hill (Pentamerus) rocks, which range by the church and Yat Hill. The Woolhope beds are completely fused near the trap rocks, at Stanner, and at the

* Leland's Itinerary, vol. v., p. 13. † Old Stones, p. 60.

lime works of Evenjob. This interesting exhibition of Woolhope rock is the last western development of workable limestone between Radnor and the coast of Cardiganshire. Here, the geologist may see limestone strata which have been truly metamorphosed, and rendered crystalline and amorphous by

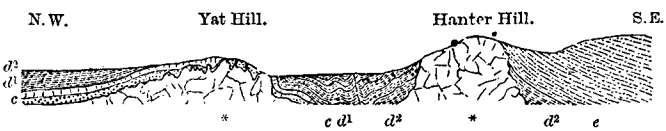
VIEW FROM STANNER ROCKS (WORSEL WOOD, HANTER HILL, AND HERGEST RIDGE BEING SUCCESSIVELY SEEN IN THE DISTANCE).



the action of heat; and here this change has been brought about by contiguous masses of volcanic rocks, which altered the stratified deposits; but, judging from the appearance of the beds towards the west, the metamorphism does not appear to have extended over any large surface.

It is interesting to the physical geologist to remark how the Llandovery conglomerate clings, as it were, in bosses to the sides of several of the hills in this district, on the western flanks of Old Radnor. Boulders of this conglomerate are scattered all over the country to the east, and it is my

belief that all these volcanic hills were covered, nearly to their summits, by this conglomerate, which they upheaved; and that the present exhibition of so much hypersthene rock is owing to denudation having cleared off a great part of this Llandovery crust, which thus swept round and over the trap hills of Stanner,



e, Ludlow Rocks. d^2, Wenlock Shale. d^1, Woolhope or Lower Wenlock Limestone. (partially altered, with serpentine faces). c, Upper Llandovery, in parts altered. * Eruptive Rocks (syenite, greenstone, and hypersthene rock).

Worsel, Hanter, and Old Radnor. These hills are severally 1000, 900, 1200, and 1100 feet above the sea. We have an instance here, too, of how faulting by volcanic disturbance, in conjunction with denudation, determines the direction of valleys, by elevating hard traps against soft shales. Thus the vale between Stanner rocks and Worsell wood has been cut out of Ludlow shales between two masses of hypersthene.

We would advise every geologist, botanist, and lover of scenery, to visit Old and New Radnor. The neighbourhood was admirably described, and its geological wonders defined by Sir R. Murchison, in 1838, in his "Silurian System," but, as he says, although within one hundred and fifty miles of the metropolis, and within a few miles of Kington, he could not learn, when visiting the country a few years ago, that any "foreign gentleman," or traveller from a distance, had come to explore this interesting district, so remarkable for its ancient volcanic outbursts, rock metamorphism, and for its abundance of fossils. And it is not the hypersthene rock or lava eruptions of Old Radnor and Stanner, or the altered Lower Wenlock beds that call solely for attention. Within a walk are also the old shingle beaches of the Upper Llandovery period; the Upper Silurian rocks full of fossils at "Water break its neck;" and on the hill sides and summits

lie the relics of the Lower Old Red and Downton beds, upheaved high above their former horizons by the volcanic and earthquake forces which acted from below. Here, also, the antiquarian may meet with many a record of past historic days, and may perchance detect some relic of a human race who lived in still more ancient times.

The earlier name for Old Radnor was Pen-crûg or Pencraig, from its situation on a rocky eminence, and its castle is mentioned by Giraldus Cambrensis under the title of "Cruker Castle," a corruption, according to Hoare, from "Crûg caeran," alluding to the height on which the fortification stands. I find that Camden tells us that Old Radnor was called by the Britons "Maesyved-hen," and from its high situation "Pencraig." Also that it was "burnt by Rhys ap Gruffydh in the reign of King John."* We may presume that this was the same Welsh prince who dined with Giraldus at the Bishop's Palace in Hereford, and who afterwards met him at New Radnor.

New Radnor is where Giraldus commenced his Itinerary. Leland, speaking of the place in the time of Henry VIII., says: "The castle is a ruine, but that a pece of the gate was amendyd. The towne was defacyd in Henry the fourth dayes by Owen Glindour." And again he says "the voice is there," "that after he wonne the castel he took a 3 score men that had the garde of the castel and causid them to be behedded on the brinke of the castel yarde, and that sins a certain bloodeworth groweth ther wher the bloode was shedde."

Again, within a walk of Radnor is the beautiful district near Kington in Herefordshire, where igneous masses rise precipitately through Upper Silurian strata, on the rocky hills of Stanner, Worsel Wood, and Hanter Hill. The eruptive rocks are protruded through sedimentary deposits of Lower Wenlock age (Woolhope limestone). Here, too, is another example of how some of the rarer of our British plants select the isolated traps for their habitats. I visited the Stanner rocks with Sir William Guise, some summers ago, in the month of June; and

* Gibson's "Camden."

we gathered Lychnis viscaria, and Scleranthus perennis, in considerable abundance. They seemed to flourish well on the black old lava, and the botanist may search the neighbourhood far and near without finding a single specimen of these plants on any other hill side. Lychnis viscaria particularly affects trap rocks and hills with volcanic ingredients in their composition, and Sir William Jardine informs me that it grows plentifully on Arthur's Seat near Edinburgh, where rocks of Carboniferous age are traversed by volcanic masses; and Mr. Pengelly has observed this plant growing under like circumstances in Cornwall.

The term "valley of elevation" does not convey an adequate idea of the wonderful geological history portrayed in the valley of Woolhope. The central dome of Haughwood is occupied by the May Hill rocks with Pentameri, and encrinital stems, (the central nucleus being no doubt composed of some far older formation, probably Cambrian or syenitic rocks); around the May Hill beds, the Woolhope limestone circles dip away on all sides under the Wenlock shale and limestone, and these again under the Ludlow rocks and Old Red Sandstone. The Woolhope district in its extension from Marcle to Mordiford may be denominated as an elongated, pear-shaped, mass of Upper Silurian deposits, which were elevated through the overlying Old Red Sandstone, and were then denuded down to the May Hill beds at the dome of Haughwood.

Thus the Woolhope district offers a peculiarly instructive history to the physical geologist, for when, after studying the rocks across and around this area, he beholds the shales hollowed into valleys, and the tilted limestones standing out like the walls of an encampment, he cannot doubt that the stratified masses now occupying hills far asunder, were once parts and portions of strata which were formerly conterminous, and joined together, and all of which must have swept nearly horizontally over the rocks which now form the dome of Haughwood. It is evident that earthquake agency upheaved the Silurian rocks through the overlying Old Red deposits; but that great power denudation has also wrought with

tremendous force; for scarcely a fragment is left of the rock masses that once formed the roof, or overlying crusts of the elevated strata, which must have been denuded and carried off as the elevatory movement was gradually going on.

Sir R. Murchison mentions in a note of "Siluria," that one of the most striking features for the consideration of geologists is, that neither the central dome, nor the surrounding ridges, including the outer encircling ring of Ludlow rocks, offer a trace of drifted matter or gravel, nor even any remnants of the various strata which must, in the process of elevation, have been first bent over, and afterwards demolished. All the débris resulting from the destruction of this once great solid mass have therefore been swept out; the tract being one of clear denudation. A few years ago I should have agreed with Sir R. Murchison; but I have since obtained evidence that the dome of Haughwood is not so deficient in drifted matter as was formerly supposed. This tract is covered with wood, and is difficult to examine, as there are no streams or gullies of sufficient depth to afford sections. When, however, I visited the district some years ago with Sir Charles Lyell, he directed the attention of the Rev. F. Mereweather, rector of Woolhope, to the question of drift gravel, and since that Mr. Mereweather has shown me several pebbles of quartz and other rocks, foreign to the district, which he himself gathered in the woods on and around the dome of Haughwood. For a long time I was disposed to attribute the presence of these pebbles to road mending or some other local transportation, but Mr. Mereweather has since discovered too many erratics in Haughwood to admit of such an interpretation. The fact is, drift gravels are much more masked by woods and pastures than we are aware of, until some circumstance leads to their discovery. Such was the case with regard to a large deposit of drift, and stratified sand and gravel, which caps a hill two hundred feet above the river Lugg at Wilcroft and Hagley (Lugwardine), east of Woolhope. The existence of this deposit was absolutely unsuspected by all the local geologists, myself among the number, until my atten-

tion was directed to it, when it was being quarried for ballast for the Ledbury and Hereford railway, by Lady Emily Foley. This drift was evidently transported from the north east, and not from the Woolhope country hard by. It is not merely a high level Lugg drift, but it appears to have been deposited by a broad stream which flowed from the Church Stretton district, partly, and only partly, in the direction of the existing Lugg. The pebbles are arranged like those of any other river drift, and the gravels are interstratified with thin beds of sand and clay. Imbedded here and there were large masses of Old Red Sandstone, the edges of which were quite angular and unworn, and looked as if they had fallen down from the side of a cliff but yesterday. With these were blocks of Cardington grits, (Caradoc grits) from the Church Stretton district, and fragments of Dhu Stone or Clee Hill basalt, with Hope Bowdler trap and quartz pebbles, none of which could have come from the sources of the present river Lugg. So this old stream must have flowed in its bed traversed by ice masses, when the physical contour of the country, and its watersheds, were very different from the present, and before the Lugg had eroded the track in which it now flows through the vales of Herefordshire. The deposit has been quarried largely at Hagley, and Wilcroft, and has rendered to searchers the teeth of the fossil horse (Equus fossilis), and a worn molar of Rhinoceros tichorinus.

The Hereford and Ledbury railroad and the Stoke Edith station lie at the base of the hills which bound the great Woolhope hollow and its inner, circumambient, vales, but few of the travellers that rush by have the slightest idea of the beauty of the view from the edge of the hill which rises in Stoke Edith Park, and displays a wonderful scene to those who can read off the Records of the Rocks with an educated eye. And to the geologist who would thoroughly examine the district, we say "go to the Foley Arms, Tarrington, between Ledbury and Hereford (now easily reached by railway), and ensconce yourself with the Survey maps, hammer, chisels and other appurtenances, in 'Sir Roderick's room,' and rest assured that a week may be

spent at that village hostelry in examining the geology of that remarkable district, and enjoying the picturesque and most peculiar scenery without fear of hazard or ennui." *

The Woolhope limestone is quarried at Scutterdine, near Mordiford, Woolhope, Westington, and Rudge End. I have obtained some noble trilobites † at Scutterdine about five miles from Hereford, and very large specimens of Rhynchonella Stricklandi have been found at this locality.

In the Malvern country the Woolhope limestone occurs at North Malvern, north of Storridge farm, and north of Crumpend. It is displayed too at "Ballard's quarry," near the Wych, where it overlies the thick mass of Woolhope or Tarannon shales which were excavated in the Malvern and Ledbury tunnel. It was cut through by the tunnel works at the western end, and Dr. Grindrod and his coadjutors obtained a rich harvest of specimens from these beds and the shales immediately below them; while the basement or true Tarannon shales were particularly unfossiliferous. The tails of very large specimens of the great Barr trilobite were abundant among the débris thrown out on the railway heaps near the western shaft, and the other beautiful trilobites, such as Phacops, Acidaspis, Encrinurus, and Calymene, in Dr. Grindrod's collection, should be seen to be appreciated. With these, were the curious Ischadites, and Spongarium, with many brachiopodous shells, while from the shales, we have Pentamerus liratus found also in the Mordiford brook in the Woolhope district, just above the May Hill beds. Another good Malvern locality for studying the correlation of this limestone with the Wenlock beds, and its position against the Llandovery or May Hill rocks, is the picturesque valley of Netherton, near Eastnor, or at Clincher's Mill, at the north-west side of Howler's Heath, at the base of the hill above the Glynch brook.

Near May Hill the Woolhope limestone is exposed on the road from Huntley to Mitchell Dean, and Ross. Here it is rather a mass of nodules and shales than a true and well

* Old Stones.

† These are now in the Malvern Museum.

bedded limestone. It is not quarried to any extent at May Hill or Huntley.

Beds of this limestone are slightly exposed on the western and south-eastern flanks of the Lower Lickey Hills in Worcestershire, at a place called Colmer's End; and in Staffordshire between Walsall and the Barr Beacon at the Hay Head.

2. Wenlock Limestone.
1. Wenlock Shale.

These strata take their name from the well known district of Wenlock Edge in Shropshire, where the hard limestone trends for miles along an escarpment, and the soft shales occupy a valley of denudation named "Apes Dale."

In North Wales and in Denbighshire, there is no trace of any of the Upper Silurian limestones, either of Woolhope, Wenlock or Aymestry, but the Wenlock shales appear near Conway, on the right bank of the river, by Llansaintffraid and Llanellan, where they overlie the Denbighshire grits. They range from Conway to Abergele, and cover a large tract of country watered by the rivers Elwy, Aled, and Alwen.

The peripatetic geologist who has been exploring the neighbourhood of Llanrwst, should go to Cerig-y-Druidion, about a mile and a half to the north of which place, the Tarannon shales and Denbighshire sandstones occur in due succession, and on the hill to the south, Garn Bris, are beds of conglomerate, which overlie the Denbighshire grits, and are very abundant as boulders over the southern district. I imagine these beds constitute the boundary between the Woolhope or Denbighshire group, and the overlying Wenlock shales of the Geological Surveyors. The country here is covered with drift to such an extent as to make physical geology difficult to work out; but from the frequent occurrence of the conglomerate in boulders, over the tract occupied by Lower Silurian rocks, S.W. of the Denbighshire country, I infer that the Wenlock beds were extended much farther to the S. and S.W. than at present. As it is, the Wenlock series, above the conglomerate, cover the wide expanse of country stretching from Conway to the north

of Corwen, and range beyond Llangollen in the direction of Oswestry, and also surround the Vale of Clwyd.

The fine range of hills of the east side of the Vale of Clwyd, including Moel Fammau (1845 feet) and Moel Fenlli (1600 feet), are composed of Wenlock strata which extend north and south from Diserth near Rhyl, to Moel-y-Gamlin near Llangollen. Both these elevated mountain peaks were fortified by the Ordovices to shield themselves against the incursions of the Romans.

On leaving Cerig-y-Druidion, the geologist should by all means visit Pont Glyn Diffiws, near the confluence of the Geirw with the Alwen, and then pass on over the drift covered hills to Ruthin, thus following a route once taken by Camden, who speaks of a lettered stone he saw at Clogreainog, inscribed:

AIMILINI TOVISAG.

Ruthin stands on the right bank of the Clywd, nearly in the centre of the celebrated vale of Clwyd. In the immediate neighbourhood we may see the rocks of the Trias; Permian shale, in which plants were discovered by Mr. Maw, and determined by Mr. Etheridge of the Geological Survey; curious patches and strips of Old Red Conglomerate; and the Wenlock rocks elevated into rolling hills. The antiquarian notes on the ancient buildings of Ruthin are not uninteresting. The castle obtained its name "Rhyddin" or the red fortress, from the colour of its stone, and according to Camden it was built by Roger Gray, in the time of Edward I. But few fragments of the pile now remain. In A.D. 1400, Owen Glyndwyr assailed the fortress without success, and, as his custom was, burnt the town, and pillaged the inhabitants. Churchyard in his "Worthines of Wales," thus described it in the reign of Elizabeth.

"This castle stands on rock much like red bricke,
The dykes are cut with toole through stonie cragge,
The towers are hye, the walles are large and thicke,
The work itself would shake a subject's bagge,
If he were bent to buyld the like agayne."

Camden represents it in his time as "a stately and beautiful castle," and Dr. Goodman, Dean of Westminster, a famous divine, and the patron and friend of the historian, was buried in the Church of Ruthin in 1601. The castle was held for Charles I. in the time of the Civil War, and was dismantled in 1646.

In the Llangollen country, the Wenlock shale is worked for roofing slates in the valley of Glyn Ceiriog. Fossils may be found near Pontdolderwen, and at Craig-ddu-alt, on the crest of the hill, near the rivers Ceiriog and Dee. The Actinicrinus pulcher was obtained at Nant-gwr-hyd-uchaf, on the south flank of the Ceriog. Wenlock fossils occur also on the summit of Dinas Bran, a conical hill rising six hundred feet above the Dee. On this rounded hill are the ruins of an ancient British fortress, said to have been built by the Britons before the Roman invasion. In 1200 it was the residence of Madoc ap Gryffydd, the founder of Abbey Vale Crucis. He died at Dinas Bran and was buried in the abbey. The Pyrus intermedia of botanists grows on the hill, also one of the rare Hieracia, and, as a native informed me, "a blood-wort." He could not find a specimen to show me, but I imagine it to be the houndstongue (Cynoglossum). The fortress was deserted and demolished before Leland's time, for he saw it in a state of decay, and mentions that an eagle used regularly to build her nest among the ruins every year, and that the robber of her eaglet had to shield himself by having his head protected by one basket, while he was lowered down for the purpose in another. ("Itinerary," vol. v. p. 51). Eagles have been extinct for some years in Wales, and even the kite (Milvus regalis) is rare, although the last time I was on Moel Fenlli, I saw two soaring among the clouds.

South of Llangollen, and Llansiantffraid-glyn-Ceiriog, there is the large area of Lower Silurian rocks, reaching from Corwen, Llanr-haiadr-moch-nant, and Llanfyllyn, to Welshpool, from which the overlying rocks have been denuded. South of Meifod the Upper Silurians again set in and range over large tracts of country. At Llanfyhangel, south-west of Llanfyllyn, and

between Meifod and Welshpool, round the Long Mountain east of Welshpool, and from Montgomery to Bishop's Castle, are large outliers and patches of Wenlock shale, which must once have been continuous with the rocks of Llangollen and Denbighshire.

South of Newtown, the Wenlock shale runs like a wedge by Llanbister in Radnorshire, and west of Radnor forest, to Llandrindod, Builth and Llangammarch, being everywhere overlaid by Ludlow rocks which range at a short distance eastward of the Wenlock beds. They also extend to the east of the Llandeilo upheaveal of Builth and Llandegley.

In the Builth district these shales are full of concretions, which occasionally contain fossils in the centre. They put on a brecciated appearance at their base up the river Yrfon at Maes-cefn-fford.

In the neighbourhood of Llandovery and Llangadock, the Wenlock shales overlie the Llandovery rocks and Tarannon shales. Near Llandovery the beds may be seen between Blaendriffyn-garn, and Pont-ar-llech, and in some localities the strata are nearly vertical. Southwards, the shales range from Llangammarch and the Yrfon river, dipping east, under the escarpment of the Lower Old Red Rocks, of the Mynydd Essynt and Mynydd-Bwlch-y-groes. They occur also along the escarpment of Myddfai.

The Wenlock shale is not developed farther south than Llanarthney, a place between Llandeilo and Caermarthen. In South Pembrokeshire, however, these beds again make their appearance near Marloes, where they occur on the coast, and are faulted through Old Red Sandstone.

In the Church Stretton district the Wenlock shale may be seen about Bishop's Castle. It may be examined between Snead and Minetown, and it occupies a considerable area towards Montgomery on the north-west, and reaches to Newtown on the west. The best place, however, to study the physical position of the beds in the eastern division of Siluria, is to cross from Church Stretton by the Caradoc rocks of Hope Bowdler, to the line of the Eaton brook, and mark the

hard escarpment of Wenlock limestone stretching north and south, and the denudation in the soft Wenlock shales which strike northwards to Coalbrook Dale, and Buildwas, and southwards by Clungunford to Wigmore, and Burrington near Leintwardine. They are also seen between Presteign and Titley, where they overlie the Woolhope limestone of Knill; and north of Old Radnor, between that place and Kinnerton Chapel.

In the May Hill country, the Wenlock shales are best seen on the eastern side of the hill, where they stretch from near Flaxley in a northern direction, and almost meet the prolonged stem of the pear shaped elevation of the Upper Silurians of Woolhope. On the western flank of May Hill these beds strike from Blaisdon to Aston Ingham. Numerous fossils occur in the shales.

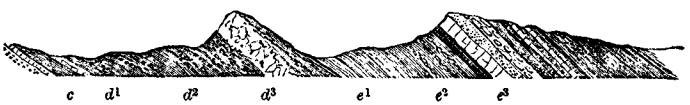
In the Usk district, the Wenlock shales occupy a large central area, and are the lowest strata exposed, for the Woolhope limestone, if it occur at all, is not brought to the surface. They may be seen at Bryn Craig, Craig-y-Garcyd, Glascoed, Radyr Mill, and Tucking Mill, which is about the centre of the district. The mineralogical character of the Usk beds differs very much from the Woolhope, and Malvern tracts, being more sandy, and marked by a Lower Silurian appearance, which caused some trouble in the early days of Silurian geology, for Sir H. de la Beche, and Sir R. Murchison thought, from their mineral structure and position, that they must be Caradoc rocks or Llandeilo flags, save that no Ogygia Buchii had been discovered in the strata. Their true geological position was ascertained by Professor Phillips.

WENLOCK LIMESTONE.

This formation consists of a concretionary limestone in which occur large nodules of pure carbonate of lime. It is quarried near Wenlock as a flux for smelting iron. The limestone may be seen in its greatest development at Benthall Edge, and may be traced by Wenlock Edge on its southern strike. Benthall Edge overhangs the river Severn, opposite

Coalbrook Dale, above Ironbridge. In both these localities the escarpments are rich in corals, remains of encrinites, and various shells. Trilobites are abundant, and heads, tails, and body rings lie among the stones in every direction and sometimes cover whole slabs as at Dudley.

GENERAL ORDER OF THE UPPER SILURIAN ROCKS INCLUDED BETWEEN THE UPPER LLANDOVERY (MAY HILL) SANDSTONE AND THE OLD RED SANDSTONE.



c, Upper Llandovery Rock, occasionally a Limestone, but often a Pebbly Sandstone. d^1, Shale, with Lower Wenlock or Woolhope Limestone. d^2, Wenlock Shale. d^3. Wenlock Limestone. e^1, Lower Ludlow. e^2, Middle Ludlow or Aymestry Limestone. e^3, Upper Ludlow and Tilestone. *f*, Bottom of Old Red Sandstone.

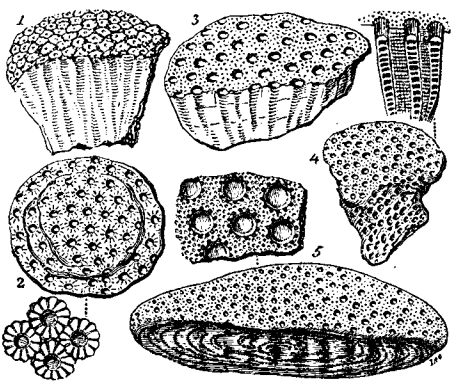
We must not forget an interesting phase in physical geology. When standing on the abrupt escarpment a few miles south of Wenlock Edge, and looking across the valley of Wenlock shale, over the Caradoc rocks beyond, to the hills of Caer Caradoc, we see a mass of insulated and vertical Wenlock limestone at Botville, on the other side of the Caradoc hills, caught up between the Caradoc rocks and the Cambrians of the Long-mynds. Thus we learn the interesting fact that the thick limestone on which we stand at Wenlock Edge must once have been prolonged across the vale, across the Hope Bowdler district, and that it was once spread out where the Caradoc hills and the Lawley now rise. What a history of the elevation and denudation of rock masses have we before us in this single view.

It is generally allowed that the geologist when examining and working among this limestone at Wenlock, Dudley, in the valley of Woolhope, or in the Malvern and Ledbury district, is looking upon rock masses, which were originally formed under conditions similar to those now observed in many parts of the intertropical world, where the coral animal secretes its stony home and forms enormous coral rocks. In the Wenlock limestone much the same class of elements are combined in its production, as those described in the present day by travellers

who have studied the living corals and their habitations. Mr. Charles Darwin, Professor Jukes and others, have done much to enlighten us on this subject of late years. We learn that in almost all tropical seas, the shores are lined with masses of coral, occurring in banks along the coasts and called Fringing reefs by Mr. Darwin. Secondly, there are barrier reefs, which have a deep and navigable channel between their edges and the shore, such as the barrier which extends along the north-east coast of Australia in a regular chain, nearly 1300 miles in length, by 10 to 100 miles in breadth. Thirdly, there are coral Atolls, which are coral rocks, at a long distance from land. They are believed to be huge coral structures built upon a descending and sinking area of submarine land. These Atolls often rise from great depths to the level of the waves. Masses of coral, sometimes 500 miles in length, and 50 or 60 miles in width, occur over vast surfaces in existing seas. Prof. Jukes calculated that in the "Coral Sea," between Australia, New Caledonia, and the Louisiade, there is "an area of something like a million of square miles over which carbonate of lime is being deposited in great sheets, and in bank-like masses, which are, in some parts at least, more than 1000, probably more than 2000, feet thick." Many marine animals frequent the coral reefs. Certain fishes, and large holothurias (sea slugs), subsist upon the living coral animals. Large Tridacnas (Hippopus maculatus) are found among the reefs, and are imbedded in uplifted coral surfaces. These Mollusca flourish in the midst of masses of Meandrina, and Porites, precisely as the Strophomena and various shells existed among the Chain and other corals in the days of the Wenlock limestone. Mr. Maw informed me that all the Wenlock corals described by M. Edwards and Jules Haime in the "Palæontographical Monograph," may be found at Benthall Edge. It is worthy of remark that the more ancient corals, viz., those found in Palæozoic strata, have a quadripartite arrangement of their lamellæ, or stony plates, the number being 4, 8, 16, &c., while in the newer or Neozoic type, the number is 6, or a multiple of 6, as 6, 12, 18, 24, &c.

With regard to the extension of the Wenlock strata, it is more than probable that they are prolonged over a very considerable area of eastern Siluria, and underlie the Upper Ludlow rocks in sheets, eastward of the Church Stretton fault. Wenlock Edge may have been a barrier reef, which was formerly pro-

CORALS OF THE WENLOCK LIMESTONE.



1, Heliolites tubulatus, Lonsd. 2, H. petaliformis, Lonsd. 3, H. interstinctus, Wahl.; a variety with large tubes. 4, 5, H. interstinctus, Wahl.; ordinary variety.

longed to the outlying mass at Botville. But the extension westwards, seems to have ceased at this point; for there is no sign of any limestone associated with the shales after passing the Botville limestone on the north, or the Woolhope limestone on the south at Old Radnor. I am not aware that the Wenlock limestone crosses, in any instance, the fault which brings up the Longmynd Cambrian rocks in the Church Stretton district, and which runs by Clunbury and Presteign to Old Radnor.

It thins out rapidly in its south-western range, being but slightly represented near Ludlow, and still less so in the neighbourhood of Aymestry.

At Buildwas, the relation of the Wenlock shales, on which the Abbey stands, with regard to the overlying limestone may be

observed. Fossils have been found here in abundance in a shaft sunk in the Wenlock shales for coal by a landed proprietor in the neighbourhood, contrary to advice given by myself.

But before proceeding on farther geological investigations, the traveller should linger awhile among the ruins of the once far-famed Abbey of Buildwas. Our notes from the accounts given by antiquarians, inform us that these picturesque ruins are the remains of a noble Cistercian edifice, founded in the same year that Henry I. died, in consequence of eating lampreys, after a day's hunting in the woods of Lion la Foret in Normandy. Stephen confirmed the foundation in 1139, and there are some instructive examples of the transition from the pure Norman style of architecture, to that of the Pointed period which superseded the massive round arch and chevron mouldings. Leland mentions Buildwas Abbey in his "Itinerary," and attributes its foundation to Matilda de Bohun, as also does Camden.

Near Leighton is The Grove, between which and the Birches, a landslip occured in 1783, which was attributed to an earthquake and caused immense sensation at the time. A large mass of earth and wood was precipitated into the Severn, caused it to overflow its banks, and "turned it out of the bed which it had enjoyed for countless ages." And "while some of the spectators picked eels and fishes on dry ground, others of different taste looked for curious fossils among the ruins of the rock, which in the morning formed the channel of the Severn, and a great many were found bearing the impression of a flying insect, not unlike the butterfly into which silkworms are changed." These we need hardly say were the tails of trilobites.

The celebrated Abbey of Wenlock is said to have been founded about the year 880, by Milburga, a daughter of King Merewald, and granddaughter of the savage Penda, King of Mercia. Milburga was the Lady Abbess of Wenlock Abbey, and according to William of Malmesbury, who wrote in the time of King Stephen, when the abbey church was rebuilt during the reign of Edward the Confessor, the tomb of St.

Milburga was broken open, and such a sweet odour came from it as to work many miracles and cure the king's evil.

In Doomsday Book, Wenlock is called Patinterne Hundred, and the last restorer of the 14th year of William the Conqueror, converted it into a monastery. Leland describes it in the reign of Henry VIII. as "a marketт towne where was an abbey of blak monkes, passing over a high hille, called Wenlock Edge." Camden says that it was then "famous for limestone," but had been formerly celebrated for a copper mine in the days of Richard II. The church is ancient and contains a noble Norman font. When I was there some years ago with the Worcester and Malvern Field Clubs, the Rev. Mr. Wayne explained the many interesting features it possesses, and also directed our attention to a note in the registers of the parish, to the effect that on a certain Sunday during the reign of "Good Queen Bess," the people of Wenlock for the first time heard the church service performed in the English language. When visiting Wenlock Edge, the geologist cannot misunderstand the position of the two different series of Wenlock strata, for deep denudation has affected the shales in a line parallel to the limestone of the Edge, and between that ridge and the Caradoc Hills. The shales are also to be seen dipping everywhere beneath the limestone, which is well exposed in many quarries on the summit and slope of Wenlock Edge.

There is one locality in the Wenlock series, not far from Ludlow, which offers many points of interest. This is Wigmore, which lies in a great valley of denudation, the Aymestry rock of Bringwood Chase rising in a bold escarpment on one side, and that of Gatley on the other. Here we have a fine example of a broken anticlinal of Aymestry limestone, with a valley of denudation in the lower strata down to the base of the Wenlock shales. The drift of this district should be investigated by local observers, for it was from the old gravels above Wigmore Lake, that the Rev. T. T. Lewis obtained some specimens of lias gryphites.

The ruins of Wigmore Castle demand attention from the antiquary. According to Camden there was a stronghold here

in Saxon times called "Wyn-gunga-Mene," which was "repaired in ancient times by King Edward the Elder," son of King Alfred (A.D. 901), and was afterwards "fortified with a castle by William Earl of Hereford, in the waste of ground (for so it is in Doomesday Book) which was called Marestun, in the tenure of Randulph de Mortimer, from whom those Mortimers that were afterwards Earls of March, were descended." (Gibson's "Camden," p. 576.) Here once lived the notorious Mortimer, paramour of Isabella of France, and the murderer of Edward II. Years after his execution his estates were restored to his son by Edward III., and from that period they remained in the family which sent forth a king to the throne of England in the person of Edward IV. In the Wars of the Roses we find the Duke of York, father of Edward IV., "retiring to his castle of Wigmore," shortly before the defeat of Wakefield, in which battle he lost his life, and after which his head was planted over the gates of York by order of his victorious enemies. Five Earls of March, with many other of the Mortimers, were buried in Wigmore Abbey. Not a memorial now remains of their sepulture, save a record by Mr. Gough in his additions to "Camden" (vol. ii. p. 454), that there was found among the mouldering walls "a stone coffin, with a small urn holding ashes, with some silver coin in the leaden coffin, which contained a body perfect, but which mouldered on the opening." In all probability this was the body of one of the ladies of the Mortimers, the ashes in the little urn being the remains of a lover or husband who perished in some foreign war, and which were placed in the same tomb with the corpse of her who had loved him through life.

In the Dudley country, the Wenlock limestone forms the heights of Castle Hill and the Wren's Nest. The hills of basalt near Rowley are witnesses of the violent volcanic action which protruded the Upper Silurians in this neighbourhood through the surrounding coal measures. The Wren's Nest is an upraised dome, resembling, on a small scale, the elevations of the Usk and Woolhope districts. The galleries, worked in the two bands of limestone here developed, are well worthy of

observation. Some splendid collections of fossils have been made at Dudley, especially of Trilobites and Encrinites, for which the Wenlock limestone here has been justly celebrated. Such were the collections of Captain Fletcher of Lawnswood, and Mr. Gray, the former of which has been sold to Manchester, and the latter to the British Museum. The Dudley Museum also contains some specimens of characteristic fossils.

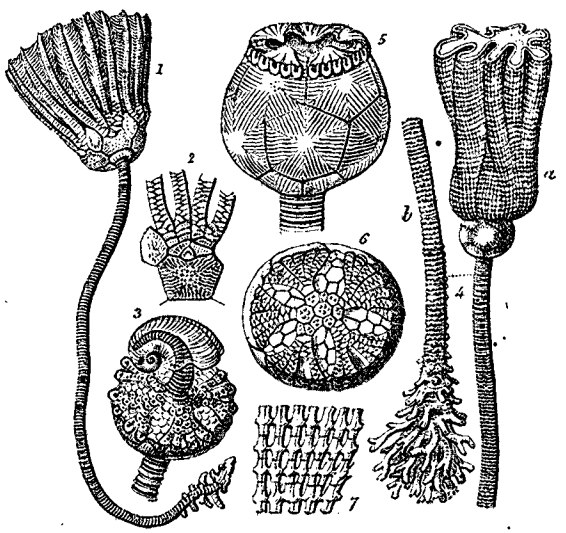
In the Woolhope district, the geologist will detect the limestone at a distance by its well-marked hills and escarpments. The hill of Haughwood is encircled by a broad valley, eroded by denudation in the soft Wenlock shales. It varies from a quarter of a mile to a mile in width. Fossils abound in many localities, as at Checkley Common, south of Stoke Edith, and at Warslaw, where some good sections also occur. The limestone quarries at Dormington, in the Woolhope valley, furnish many excellent specimens of Wenlock corals, and many Wenlock brachiopoda, more especially the Strophomena euglypha, which appears to have lived among coral reefs, and which, with Strophomena depressa, is found glistening in the sun with a peculiar metallic hue. Here also is the common Wenlock fossil, Atrypa reticularis, with small corallines clustering on shells that drifted about dead on the Silurian reefs, before the coral animal became attached to the separated valves. The Dormington coral reef is now in a strange position, circling, as it does, within an escarpment of Aymestry rock, by which it is almost enclosed, as by a wall; and yet this limestone, 500 feet thick, elevated by volcanic agency, and from above which thousands of feet of solid rock have been denuded, now furnishes the condensed relics of millions of extinct animals. Every particle of the limestone, now utilised in so many different ways by man, once passed through the laboratory of life!

In the neighbourhood of the Malvern Hills, the Wenlock shale and Wenlock limestone much resemble, on a diminished scale, the correlative rocks in the typical district of Wenlock Edge; the former occupying the valleys and slopes, and the latter rising into low hills. Next to the escarpments of

Wenlock, and Benthall Edge, this is perhaps the best district for examining this rock, as the Ridgeway of Eastnor Park somewhat resembles Wenlock Edge in its prominent outline. On the western flank of the southern Malverns, these strata occur near Clincher's Mill, Eastnor, the Glynch brook running between them and the Woolhope limestone at the base of the hill of Howler's Heath. From hence they may be followed by Eastnor Park and its lake, to the valley of Netherton, where they are highly fossiliferous, and furnish many brachiopoda such as Strophomena euglypha and S. depressa, with the trilobites Phacops caudatus, P. Downingiæ, and Calymene Blumenbachii. Phacops Downingæ is generally found rolled up like a woodlouse. The eyes of this little trilobite are often beautifully preserved. Another good exposition of these beds is north of the Herefordshire Beacon between Winnings farm and Stonesway, and from thence to Croft farm. Northward of this it is developed between Storridge farm and Cradley toll bar. There are sections at Winnings farm, Colwall Copse, and Croft farm; and many of the fine fossils in Dr. Grindrod's Museum, and in the Museum of the Malvern Field Club at the College, Great Malvern, were found in these quarries. At Winnings quarries especially, very perfect Orbiculas are obtained and occasionally some fine Trilobites, with most of the typical shells. Colwall Copse is also a good locale for Trilobites, and my old friend and coadjutor Mr. Dyson collected many fine specimens there in days gone by, and especially is it rich in that curious Pteropod, Conularia Sowerbyii. Purlieu Lane is a little watercourse with many a wild flower on its banks, and which, ascending from Brockhill Copse, affords sections of the Ludlow rocks, and near Malvern, of Wenlock shale and Wenlock limestone. An instructive walk may be taken from Malvern, up the Serpentine valley and across the hills to the Westminster Arms. Then, following the road towards Mathon, we may examine the May Hill beds and a narrow strip of Woolhope rock. We soon arrive at a broad band of Wenlock limestone, and this quarry near the Mathon road is especially famous for good specimens of the Acroculia

haliotis, a univalve mollusk which has sometimes been found in the embraces of an encrinite, with its proboscis inserted in such a way into the shell, as to lead us to suppose that the Acroculia was being devoured by the Enerinite, when death came upon both, on the site in which they are discovered.

CR'NOIDEA OF THE WENLOCK LIMESTONE.



1, Marsupiocrinites cælatus, Phil. 2, Magnified base of the arms. 3, Proboscis of the same inserted in the shell of Acroculia haliotis. 4, Reduced figure of Crotalocrinus rugosus, Miller; the bag-like cluster of arms surmounting the small, round 'pelvis.' 5, The latter, of the natural size, with the stomach-plates stripped off, and showing the base of the many-fingered arms. 6, The flat stomachal surface, showing also the branching of the arms from their bases. 7, A part of the reticulate congeries of fingers, each joint being anchylosed to its neighbour on either side.—[J. W. S., 1859.]

The Wenlock limestone may be followed northwards to the river Teme. It is exposed in some remarkable positions on the ridge called Watts Hill, where some of the dislocations and disturbances are exhibited in sections which afford excellent practice to the physical geologist. From Martley the limestone trends northwards on the line of the Abberley upheaval. It is seen about Collins Green, in the northern part

of Ankerdine Hill, and ranges from Hill side under Woodbury Hill. North of Martley, there is a ridge of Wenlock limestone with many typical fossils.

In the May Hill district, the Wenlock limestone overlies the shales on their strike from Blaisdon to Aston Ingham. It occurs also at Ristley Wood and at Jordan's Wood. It is extensively quarried for limeburning and building purposes, particularly on the western side along Blaisdon Edge, and on the strike of the limestone along the line of the Michell Dean road, the beds are stained red. It has been calculated that the whole thickness of the Wenlock limestones in this district is about 220 feet. Fossils are numerous, the gasteropodous shells Euomphalus discors, and E. rugosus, occurring plentifully in both shales and limestones. Athyris tumida, a typical brachiopodous shell, common in these strata, is here often found covered with a beautiful coralline or bryozoon, the Fenestella assimilis. A good collection of fossils from this district may be seen in the Museum at Gloucester. They were obtained by Mr. John Jones, formerly the Hon. Secretary of the Cotteswolde Field Club, and an accomplished naturalist.

At Tortworth the Wenlock limestones range from Crockley farm as far as, and beyond Whitfield. This is a contorted, difficult district, not to be explained without going into considerable dissertation. The maps of the Geological Surveyors are absolutely necessary here for a stranger whose time is limited. Fossils are found at Whitfield.

In the Usk district, this limestone forms nearly a continuous band round the dome of Wenlock shales and is seen at Trostrey, Radyr, Prescoed, Glascoed and Tynewydd. Fossils are plentiful and similar to those found near the Malvern Hills, Woolhope and May Hill.

In Marloes Bay, Pembrokeshire, rocks have been observed containing Wenlock fossils. Not far from the great fault in the cliff are thin limestone bands with corals, and from these, we pass upwards to the Ludlow series and the Old Red of West Dale point.

A singular patch of Upper Silurian rocks is also exposed at Pen-y-Llan, near Cardiff. They have yielded both Wenlock and Upper Ludlow fossils to the researches of Mr. E. Lee.

LUDLOW ROCKS AND PASSAGE BEDS.

In the districts of Wenlock, Malvern, and Woolhope, where different beds of limestone are developed, the Wenlock lime-

LUDLOW CASTLE.

(From a Sketch by Lady Harriet Clive.)

In this sketch the River Teme is seen to flow in a chasm of the Upper Ludlow Rocks, the strata on which the spectator is supposed to be standing being the same as those on which the Castle is built. The basalt of the Titterstone Clee Hill is in the distance, surrounded by Old Red Sandstone, and covered by Carboniferous deposits.

stone passes upwards into strata of grey-coloured shales, which in these typical Upper Silurian provinces, separate the Wenlock from the Aymestry limestone, and form usually the inner slope of the hills of Ludlow rocks, which, on their external slope, throw off the Upper Ludlow shales and passage beds, and Old Red Sandstone.

In other parts of Wales, where the Upper Silurian rocks are not subdivided by limestones, it is difficult to separate the Wenlock and Ludlow formations, although the geological surveyors have succeeded in doing so to a certain extent, by means of a few typical fossils.

There are several chambered shells allied to the Nautilus

which are rare in the older rocks, but which become abundant as we ascend to the Ludlow strata; such are the Phragmoceras (phragmos = a partition, and ceras = a horn), and the trumpet-shaped Lituite. The Phragmoceras, a pear-shaped cephalopodous shell, is very characteristic of the Lower Ludlow shales, but perhaps the most typical fossil is the Graptolites ludense. Starfishes are numerous in some localities, and it was in these rocks that the oldest known fossil fish was discovered at Church Hill, near Leintwardine, Shropshire, by Mr. J. E. Lee of Caerleon. This old fossil fish is regarded by Professor Huxley and Mr. Ray Lankester as allied to the sturgeon, and belonging to the genus Pteraspis, a form which appears in several species in the Old Red Sandstone. It is the "Scaphaspis ludensis" of Mr. Lankester.

In "Siluria," when treating of the Lower Ludlow rocks, Sir R. Murchison says that his "chief reason for grouping them with the Ludlow, rather than with the Wenlock deposits, was that throughout the typical districts of Shropshire and Herefordshire these shales occupy the base of the ridges, the harder summits and eastward slopes of which are composed of Aymestry limestone and Upper Ludlow rocks." These shales then form the escarpments and contiguous valleys of the Upper Ludlow series.

In North Wales the Lower Ludlow strata are developed in the Long Mountain. In this range of hills, which rise to a height of 1330 feet, these strata underlie the Old Red rocks of the Forest of Hayes. The absence of limestone and the scarcity of fossils in this district renders it almost impossible to separate the Upper and Lower formations. The Rhynconella nucula is, however, found in thin bands in the Long Mountain, and whenever this characteristic fossil occurs in abundance, it may be considered typical of the Upper Ludlow beds, while, as the underlying deposits contain Graptolites, they may be set down as belonging to the Lower Ludlow group; at least in Siluria. On the western slope, near Gaithley, the strata contain Cardiolæ and Graptolites. On the summit of the Long Mountain is a fine earthwork, named Caer Digol, and here the

last battle for Welsh independence was fought by Madoc against Edward I. in 1294.

The Lower Ludlow strata occupy undulating tracts of country between the Kerry hills, south of Newtown, in Montgomeryshire, and Bishop's Castle. They are quarried in Kerry Hill, and are found to contain Cardiolæ and Graptolites, and they are also exposed on the eastern side of Clun Forest.

South of the Long Mountain, the Upper Ludlow beds are denuded until we arrive at the Clun district, where they underlie and support the great Old Red outlier of Clun Forest, which rises to the height of from 900 to 1300 feet above the sea, and forms a trough, in the centre of which rests the Old Red of the Forest. They are exposed in the railway quarries at Knighton, and they also support the outliers of Old Red Sandstone near Brampton Bryan and Presteign. The neighbourhood of Knighton in Radnorshire, is favourable for the investigation of both Upper and Lower Ludlow rocks. The town itself is built upon the right bank of the Teme, which has its source in Lower Ludlow rocks on the Kerry Hills. The celebrated Offa's Dyke, "Clawdd Offa," is also seen to advantage in the neighbourhood of Knighton, or, as it is called in Welsh, "Tref-y-Clawdd," the "Town on the Dyke." This earthen rampart was raised by King Offa about 760 A.D., as a line of partition between the kingdom of Mercia and the dominions of the Welsh princes. It commences near Chepstow, on the Severn, and from thence it has been traced by Tintern to Bridge Sollers in Herefordshire, and by Knill Garroway to Knighton. It extended from thence to Basingwerke in Flintshire, not far from the mouth of the Dee, a distance of nearly 100 miles from its commencement on the Severn. The "Clawdd Offa" was a boundary of importance, for a law was passed by Edward the Confessor, after the Welsh had been defeated by Harold, that every Welshman found in arms to the east of Offa's Dyke should lose his right hand. The poet Churchyard alludes to this Dyke :—

> "Within two miles there is a famous thinge,
> Calde Offa's Dyke, that reacheth farre in length;"

And so also does Camden, who quotes "Joannes Sarisburiensis" and his Polycraticon on the question of Harold's law.

The geologist will observe a remarkable valley of denudation in the Lower Ludlow shales, along a line of fault, through which the Teme passes between the hills of Brampton and Coxwall Knoll, the strata of these hills dipping in opposite directions. He should also remember that at Pedwardine, close to Brampton Bryan, rocks as old as the Upper Lingula Flags, are faulted to the surface against Upper Silurian strata.

Every antiquarian should visit the old British encampment of Coxwall Knoll, five miles east of Knighton. The plan of the camp is given in "Roy's Military Antiquities," and Roy, supported by several authorities, believes it to have been the scene of the final struggle between Caractacus and Ostorius. The locality, however, does not correspond with the geography of the spot, as given by Tacitus, much better than that of Caer Caradoc near Church Stretton, the hill supposed by Camden to be the place where the noble Briton was brought to bay.

The Upper and Lower Ludlow strata, divested of the Aymestry limestone, cover a large area of the county of Radnor, and extend from Knighton and Presteign in a south-westerly direction. At the beautiful waterfall called "Water-break-its-neck," near New Radnor, are strata passing upwards from the Wenlock shales into the Lower Ludlow rocks with Cardiolæ, and other sections, in the hills beyond, show the presence of the Upper Ludlow beds overlying the lower deposits. The Tilestones, or Downton beds, are quarried on a hill in the neighbourhood, and they are overlaid by the Lowest Old Red.

Near Kington, the Lower Ludlow rock is seen in a section running north-west from Bradnor to Herrock Hill. Bradnor Hill, near Kington, is celebrated as showing the Passage beds in certain quarries on its southern flank. The Bone bed of the Upper Ludlow rock is there overlaid by brown-coloured strata containing a typical Upper Ludlow shell, Chonetes lata. These beds are again overlaid by strata containing the remains of fishes, especially the Cyathaspis Banksii, and portions of

the Crustacean, Pterygotus (a small species of which, as already mentioned, is first known in the Upper Llandovery beds of Eastnor, near Ledbury) and also two species of Eurypteri.

Bone beds are zones of bony and coprolitic matter which are found in strata of Recent, Tertiary, Wealden, Oolitic, Rhœtic, Carboniferous, and Silurian ages, and probably owe their origin to the sudden destruction of fish, crustaceans, and marine reptilia, by the action of volcanic gases, or some cataclysmal epidemic which destroyed vast quantities of marine animals over considerable areas in the seas of the different periods. It is probable also that bone beds were deposited in shallow water, as on the fish banks of Newfoundland. In 1868, Dr. A. Leith Adams saw the whole surface of a lagoon, known as "Anderson's Cove," in the Bay of Fundy, covered with dead fish to a depth of a foot in some places, after a violent storm. Enormous numbers, too, were floating on the surface of the water. A sudden influx of lava, or turbid mineral, or gaseous impregnated waters, in the neighbourhood of the Dogger Bank, would cause the immediate death of thousands of fish and other marine animals. Some years ago I received an account, through Mr. John Jones, then Austrian Consul at Gloucester, of the traverse of the ship Harbinger through vast shoals of dead garfish (Sygnathus anguineus), floating on the surface of the waves between Mirimachi, New Brunswick, and Gloucester. The fish were most numerous in that latitude, through which the volcanic band of Iceland, the Azores, and the Madeira passes. It is probable that these shoals were destroyed by submarine volcanic action, as no doubt was the case in many instances with the fish of our fossil bone beds.

The Bradnor quarries are very rich in fossils. When I visited them a few years ago, in company with Dr. Melville, Mr. Banks of Ridgebourne and Mr. Lightbody, we succeeded in obtaining many characteristic specimens in a couple of hours. The fish plates are abundant, although seldom found in a good state of preservation. The Lingula cornea is a fossil which demands attention, as it ranges, at Ledbury, from the

Upper Ludlow beds through the Downton Sandstone and Passage beds, into Red strata with Cephalaspis near the base of the Old Red.

The lover of geology should cross from Bradnor Hill to the Hergest Hills, and from thence to the Trewerne Hills on the Wye. Many good Upper Ludlow fossils may be obtained in the hills behind Newchurch, and close to the inn is a capital quarry with Ludlow fossils. The beds are overlaid by Old Red Sandstone and Passage beds, within a short distance of this lonely hillside village, where Sir R. Murchison was quartered for a considerable time during his investigation of the district when writing the "Silurian System." Few amateurs, I suppose, have followed out the work done by Murchison so much as myself, and know so much of the "roughing" he underwent for the pure love of geology, in the days when he was writing or collecting the materials for the work which established his fame. He remained ten days at this out-of-the-way village inn, near the sources of the river Arrow, crossing the country in every direction, and sending to Kington for provisions. I slept in his room before the "public" was repaired, and they were indeed "soldiers' quarters" that he occupied.

Shobdon Hill, between Aymestry and Presteign is occupied by the Upper Ludlow rocks. Coombe Wood, near Presteign, yields typical fossils, and the shrimplike Ceratiocaris has been found there. Some years ago I travelled to Presteign on hearing that the bones of a large animal had been found in the Lower Ludlow shale, and were to be seen in a garden near the town. The "bones" proved to be some argillaceous concretions, somewhat in the form of the ribs of a whale. It was not the first time (or the last) that I journeyed on a "gowk's errand" on the report of "a great geological discovery;" but I was somewhat comforted on finding that the veteran Sedgwick and Prof. M'Coy had left Presteign only the day before, having travelled from Shrewsbury to see "the whale."

Shobdon Church was built as early as the year 1140, by De

Merylond, steward to Hugh Mortimer, who founded a small priory near it.

In the neighbourhood of Hay, in Brecknockshire, are interesting sections showing the relations of the Lower Ludlow rocks to the Upper Series. It was here that Sir R. Murchison first observed the correlation of the strata, and their downward passage from the Old Red Sandstone into the Upper Silurians. The old red rocks occupy the Clyro and Trewerne hills, above the town, on the left bank of the Wye ; and on the N.W. they are underlaid by terraces of Ludlow rocks. The Lower Ludlow strata may be seen much twisted and contorted in a mountain gorge near Lyswen, at a picturesque spot called Craig-pwll-du, where the Bach Howy falls over a steep cliff into a pool at the base. The rocks in this romantic glen contain fossils, and the botanist may obtain the moonwort (Botrychium Lunaria) and the adder's tongue (Ophioglossum) on the woody slopes. The explorer should visit the Rhosgoch, a peat moss some miles north-east of Llanstephan, between Hay and Kington. It is apparently a silted up lake, and is now the haunt of the snipe, and many years ago, when snipe-shooting at Mrs. Griffiths's of Dolkenny, I saw a bittern rise from this marsh. Is this Rhosgoch one of the lakes said by Giraldus to have burst its banks on the night on which Henry I. expired? Or is it the Boughlinne of Leland, who mentions "a Llyinne in Low Elvel, within a mile of Payne's Castel, by the Chirch Lanpeder. The Llinne is called Boughlline, and is of no great quantity, but is plentiful of pike, and perche, and eles." *

My attention was directed by Mr. Walker of Llanstephan to a curious upright stone, known as The Druid's Stone, standing in a field not far from Llanstephan Church. It is an Old Red boulder set on end, and may be a burial stone.

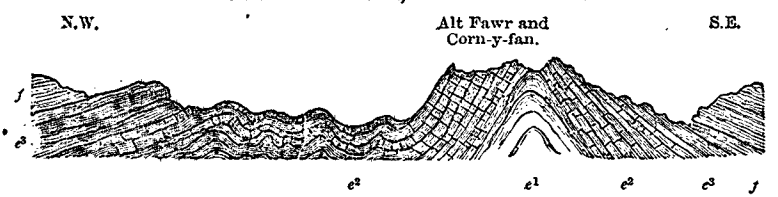
In the Brecon district the Ludlow rocks extend from Corn-y-fan, about six miles N.W. of Brecon, to Erwood on the Wye, below Builth. In this rocky and picturesque country of hills and moorlands, the geologist should visit the remarkable anticlinals of Alt fawr, and the uplift of Corn-y-fan, where the

* Leland, Itinerary, vol. v. p. 72.

Ludlow rocks are the oldest beds, and throw off at high angles the Upper Ludlows, Passage beds or Tilestones, and the Old Red rocks.

At Trecastle, in Breconshire, the instructive sections should be observed along the escarpments of Mynydd, Bwlch-y-groes

BRECON ANTICLINAL OF LUDLOW ROCKS, THROWING OFF OLD RED SANDSTONE.



e^1, Lower Ludlow. e^2, Middle Ludlow, with a calcareous band representing the Aymestry Limestone. e^3, Upper Ludlow. *f*, Old Red (lowest beds).

and Mynydd Epynt, where there are several instances of the junction of the Ludlow rocks with the Old Red Sandstones. There is a mound at Trecastle (Castletown) which was the site of an ancient fortress, said to have been the stronghold of the ancestors of the Gwyns ; and there is also a tradition that the low ground between Trecastle and the village of Llywel, half a mile distant, was formerly a lake, whereon the Chieftain's family were rowed in a fine boat on high days and holidays. An excursion among these hills and vales will convince the geologist, that ice has had much to do with the removal of the masses of strata swept out from the different valleys, not only during the emergence of the hills from the glacial seas, but also long, long after their upheaval into dry land; for everywhere we meet with evidences of the action of land ice and snow moving down the grooves of the higher valleys, and of the power of land ice and snow in carrying blocks of rocks and stranding them far beyond the parent mass to which they were originally attached. The village of Devynock, between Brecon and Trecastle, is believed to have derived its name Dyfnawg, from the deep valleys of the country ; and there are many so-called Druidical stones in the neighbourhood, which may have

been placed in position by some of the ancient inhabitants, but which assuredly owe their transport to other agencies than the hands of man. Near Horeb chapel on the valley of the Cwm Dor, between Trecastle and Llandovery, is a section affording many fossils. The Tilestones of this country are on the horizon of the uppermost Ludlow strata and Downton beds. They contain some characteristic fossils, and are also quarried at Pont-ar-lleche, near the old decayed town of Llangadock.

The geologist, when visiting the neighbourhood of Llandovery or Llandeilo, should take the opportunity of observing the way in which the Upper Silurian rocks are squeezed and faulted between the hard quartzose rocks of the Llandeilo period on one side, and the quartzose conglomerate, which runs along the ridge of Trichrug, on the other. One section may be traced from the eastern base of the old encampment of Carn Goch, near Llangadock, where the Tarannon shales occupy the lower part of the hill on the slope ascending to Trichrug, and we pass upwards, through representatives of the Wenlock and Ludlow formations, to this remarkable yellowish and quartzitic conglomerate, which extends along the crest of the hill and dips under the Old Red Sandstone. This peculiar conglomerate is on the horizon of the Downton and Passage beds. Near Llandeilo, the Upper Silurians are crushed into quite a thin line between the ridge above Golden Grove and the promontory of Nelson's monument.

From the Sowdde river to the south-west, below Caermarthen, these rocks thin out to a mere band under the Old Red, although they may be seen in Mynedd Cyfad, east of Caermarthen, at Mount Pleasant and Pont Pibwr. Without the aid of the fossils which have been detected, it would be difficult to recognise in these sandstones, the mudstones of the Lower Ludlows of Radnor. The Passage beds are represented by grey, quartzose, micaceous sandstones, and reddish marls, dipping at an angle of 41 degrees to the south-east. Junctions of the Upper Silurian rocks with the Old Red, are exposed at Croesceiliog on the road between Kidwelly and Caermarthen, and also on the Towy at Castel-Moen.

In Pembrokeshire, junctions of these rock systems are exhibited near the little town of Narberth. The geologist may examine Lower Silurians (Llandeilo beds), Upper Silurians, Old Red Sandstone, Mountain Limestone, Millstone grit and coal measures, in the course of a morning walk south of Narberth. In South Pembrokeshire, junctions of the Silurian and Old Red systems may be seen in the Bay of Freshwater, east-south-east of Pembroke, and again on the opposite side of the peninsula, west of Freshwater, near Castle Martin. In Marloes Bay, at Westdale Point, similar phenomena may be observed. The characteristic fossil of these beds is the Rhynconella navicula.

We now revert to the Silurian districts, where the rocks of the Upper series are characterised by subdividing limestones. In the neighbourhood of Wenlock Edge, the different strata cannot be misunderstood, for the Wenlock limestone of the Edge, and the Aymestry limestone of View Edge and Norton Camp, near the Craven Arms, trend away to the north-east and towards Wenlock and Coalbrookdale, in parallel ridges that cannot be mistaken. The Lower Ludlow rock occupies the trough under the Aymestry limestone and constitutes the shales between that limestone and the Wenlock limestone. I know no district where the physical position of the Lower Ludlow strata is better marked, than within a walk of the Craven Arms, near Church Stretton. Here also the Aymestry limestone forms the bold hills of View Edge and Stokesay Camp, where it occupies a wooded ridge stretching away for miles, and overhanging the Wenlock limestone. The typical fossil of the Aymestry rock, the noble brachiopod, the Pentamerus Knightii, is to be obtained at View Edge, where there is a band twenty feet thick, full of these fossils. In this district the Upper Ludlow rocks rise into the high grounds known as the Yeld, and dip by Broadstone Rough, under the lower Red strata of Corve dale, along which they trend southwards towards Ludlow, to the west of Holgate and Culmington.

It will interest the lover of physical geology to observe the

faulting of the strata, and the dislocations around the Craven Arms, caused apparently by the elevation of a spur of Cambrian rock, an outlier of the great Longmynd mass, which rises into the hilly tract to the west of Sibdon.

Worthy also of notice are the excavations in the Drift, north of the Craven Arms on the line of the railway to Bishop's Castle. After examining the sections in company with several good geologists, we came to the conclusion, that the distortions and dislocations observable had probably been greatly influenced by ice masses drifting down the valleys from the direction of Cardington and Bishop's Castle, and grounding in the drift. A great portion of the drift was composed of Cardington grits interspersed with boulders from the Longmynd. Some of them were grooved and scratched, and the whole mass has evidently been reassorted by water since its transportation from the hills. Stokesay Wood is a great resort for botanists, who often find there many rare plants to reward their researches. The Astrantia major is found here, but Mr. Bentham informs me that it is not a native British plant. In catalogues it is marked as "ambiguous."

Near Dudley the Aymestry rock is to be seen at Sedgeley, where it is elevated through the coal measures, and rises in the Beacon Hill to the height of 650 feet above the level of the sea. The characteristic fossil Pentamerus Knightii occurs in the numerous limestone quarries. Hugh Miller's first acquaintance with Silurian geology commenced at Sedgeley, and in his "First Impressions of England and its People," he gives a graphic description of his explorations among the Aymestry deposits, and his researches for their typical fossils.

Near Wenlock this formation commences at Sutton, and rises into an elevated escarpment which extends by Larden and Serefton to Mocktree forest.

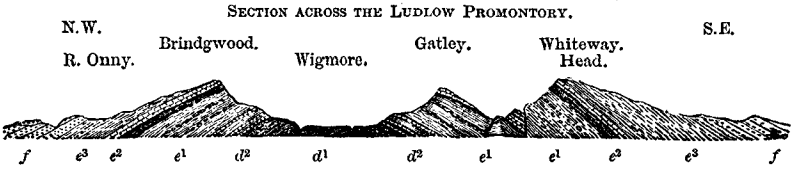
The term of Ludlow rocks was given to this group by Sir R. Murchison, because the town of Ludlow is built upon the upper beds of these grey-coloured Silurian strata, which in this district rise from beneath the Old Red sandstone into the bold hill ridges stretching to the west, north-west, and south-west of the

town. The physical position of the upper strata may be generally determined at a glance, by the way in which they slope off as rounded hills, and pass underneath the plains of Lower Old Red Sandstone; while the Lower Ludlow and Wenlock formations are exposed in escarpments and are grooved, and channelled by denudation. With the exception of being rather more micaceous, the lower strata of the Upper Ludlow rock, greatly resemble those of the Lower Ludlow; while the Ledbury or Passage beds which overlie them and pass by insensible gradations into the Old Red Sandstone, assume different characters in different localities, being in one district grey, passing into red, in another grey and yellowish, and again in another grey and blueish-grey, passing into red beds.

In the neighbourhood of Ludlow is a section given by Sir R. Murchison in his "Siluria," in which the Lower Ludlow rock is exhibited in Mary Knoll Dingle and Comus Wood. The beds afford numerous fossils; a section may also be seen in ascending from Elton to Evenhay, the ridge being a prolongation of Gatley Coppice. Here the Lower Ludlow beds are argillaceous strata underlying the Aymestry rock on the summit of the hill, and overlying the thin representatives of the Wenlock limestone. Fossils may be found at Elton Lane and Bow Bridge. Near Ludlow, the Aymestry limestone occupies the ridges of Mary Knoll (overlying the Lower Ludlow beds there exposed) and Brindgwood Chase, west of the town, and constitutes the High Vinhall, Whiteway Head, and Croft Ambrey. Mr. Lightbody of Ludlow has pointed out the close relation of the Lower Ludlow fossils with those of the Aymestry rock, and has proposed to correlate this limestone with the rocks of the Lower Ludlow series. In the Ludlow district there are, without doubt, several bands of calcareous rock in the Lower Ludlow beds which consist principally of repetitions of strata containing Pentamerus Knightii. Nevertheless the Aymestry limestone is a well-marked divisional rock in other districts, where, as, for instance, at Malvern, Woolhope, and Ledbury, no Pentamerus Knightii occurs. Geologists will

probably therefore retain the division of the strata as originally marked out by Sir R. Murchison and Mr. Lewis.

At Caynham Camp, and Tinker's Hill, south-west of Ludlow, are outlying upcasts of Aymestry rock containing the characteristic Chonetes lata, and Rhynconella Wilsoni. The upper-



d^1, Wenlock Shale. d^2, Wenlock Limestone. e^1, Lower Ludlow Beds. e^2, Aymestry or Ludlow Limestone. e^3, Upper Ludlow Beds. *f*, Old Red Sandstone (bottom beds of).

most strata present in this district, and in many localities, a remarkable feature in the "Bone bed," which at Ludlow appears as a dark brown layer consisting of a confused mass of bony fragments, the relics of some minute fish and crustaceans. "Some of the fragments," says Sir. R. Murchison, "are of a mahogany hue, but others of so brilliant a black, that when first discovered they conveyed the impression that the bed was a heap of broken beetles." The late Rev. T. T. Lewis and Dr. Lloyd were the first to discover this bone bed; they traced it in several localities around the Ludlow promontory, and observed that it was immediately overlaid by the Downton Castle beds, which are composed of yellowish micaceous sandstones, containing Lingula cornea, a fossil found also in the Upper Ludlow shales and in the "bone bed." The Downton strata may be considered as the lowest beds of the Passage rocks, or Ledbury beds of Salter.

There are many places in the environs of Ludlow where the Ledbury or Passage rocks are partially exposed, and in the railway cutting to the north-east of the town, considerably higher in position than the bone bed, they furnish remains of fishes. Mr. Lightbody has a fine collection of fossil fish and crustaceans from these railway beds, and they have afforded

many specimens to the researches of Mr. Marston, Mr. Cocking, and Mr. Salwey. Among the fish remains were Cephalaspis ornatus, and C. Murchisoni (the latter also having been detected at Ledbury) Auchenaspis Egertoni (a small fish allied to Cephalaspis), and another species, Auchenaspis Salteri, which is found in abundance at Ledbury in Passage rocks considerably above the corresponding railway shales of the Downton beds at Ludlow. These fish were described by Sir P. Grey Egerton. Among the Crustacea are Eurypterus pygmæus, and the gigantic Pterygotus Anglicus. From what we know of the Passage rocks in other localities, it is probable that all the Ludlow railway shales with their bone beds and fossils, are strata which overlie the older original "bone bed," but the river Teme runs along a line of fault which destroys the continuity of the Passage beds in the Ludlow district, and therefore it is almost impossible to determine their true sequence. It is, however, fortunately unbroken in the section exposed in and outside the tunnel at Ledbury. The best localities near Ludlow for fossils are as follows: Mocktree, Burrington, and Church Hill, near Leintwardine, Tinker's Hill, Brindgwood Chase, and Whitcliff, while for the fishes and fossils of the Passage rocks, we recommend the Paper Mills, Ludford Lane, the Railway beds, the Tin Mills, and Forge bridge near Downton.

Ludlow Castle stands on the site of an ancient stronghold erected before the time of the Norman invasion, as the British name for Ludlow was Dinan Llys Tywysog, or the Prince's Palace. The relics of the present Castle are situated on a bold wooded rock, at the foot of which runs the river Teme. According to Camden it was founded by Roger de Montgomery, Earl of Shrewsbury, and it endured a long siege by King Stephen, who at the risk of his own life rescued the young Prince Henry of Scotland under its walls, from being made prisoner by the soldiers of the Empress Matilda's army. It was from Ludlow Castle that Edward V. was removed to London, to be afterwards murdered by the order of Richard III., and here died Arthur Prince of Wales, the eldest son of Henry VII.

Giraldus Cambrensis says that it was a "noble castle" in the days of Henry II., although he does not appear to have visited either Ludlow or Leominster on his way to Hereford. He speaks nevertheless of passing by "the little cell of Brumfield," which was established, according to an ancient deed in Dugdale's "Monasticon," in the reign of King Henry I. Leland also mentions the "priory or cell of monks at Brumfield," and gives a particular description of the site of the Priory and its position between the Onny and the Teme.

The magnificent courts of the Lords President of the Marches were held at Ludlow during the reigns of Henry VIII. and of Elizabeth.

> "Here Milton sung. What needs a greater spell
> To lure thee, stranger, to these far-famed walls?"

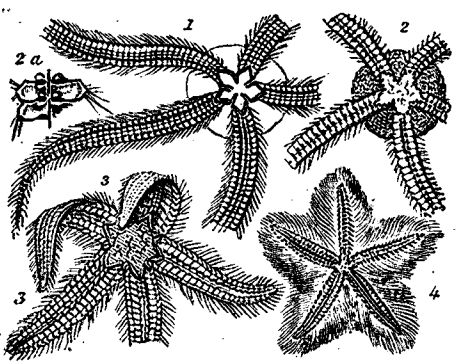
for it was at Ludlow Castle that the bard composed the "Masque of Comus" in 1634, during the Presidency of the Earl of Bridgewater. The Masque was acted in the Castle, and owed its origin to the fact of the two sons of the Earl of Bridgewater, and his daughter, Lady Alice Egerton, losing their way and being benighted in Eywood Forest. After the Restoration, Butler resided here as secretary to the Earl of Carberry, and he is said to have written a portion of "Hudibras" in one of the towers.

Ludlow Church is also a grand building. It is of early English architecture, with decorated transepts. Edward IV. sent funds to assist in building the tower. The church has been admirably restored within the last few years. When staying at Ludlow the antiquary will find a fitting haunt at the "Feathers Inn," an old panelled house of the days of James I.

Around Leintwardine, at Mocktree and other localities, are several escarpments, where the relations of the Lower Ludlow rocks may be seen. The Church Hill quarry near Leintwardine is the spot where, as already mentioned, the earliest known fish (Scaphaspis Ludensis) was discovered, and it is also celebrated for its Star-fish, Paleaster, Protaster, &c. The Leint-

wardine district appears to have been dislocated by faults, and the Aymestry limestone, containing Pentamerus Knightii, is seen north of Church Hill, on the same axial line with the Lower Ludlow beds of the celebrated quarry. It appears also that strata with fossils similar to those of the Church Hill quarry have been observed by Mr. Marston in a quarry on the west side of the old road to Leintwardine, lying between rocks bearing Pentamerus Knightii. Again, Mr. Lightbody detected a remarkable section at Mocktree, where the Church Hill quarry beds are in a trough of Aymestry limestone, and contain Star-fish, Lingula lata, and other Lower Ludlow fossils.

STAR-FISHES OF THE LOWER LUDLOW ROCK.



1, 2, Protaster Miltoni, Salter; a form of Ophiuridæ with numerous plates. 2 *a*, Small portion of a Protaster, magnified. 3, Palæocoma Marstoni, Salter. 4, P. Colvini, id. These are Star-fishes allied to Palmipes and Pteraster.

According to Dr. Thomas Wright, the antiquarian, the Roman town Bravinium stood on the banks of the Teme, near the village of Leintwardine, on the road which proceeded from Ariconium (Weston near Ross), by Magna (Kenchester near Hereford), to Uriconium (Wroxeter) on the Severn.

A note in Gibson's Camden records a perfect Roman camp called "Brandon, near Lanterdin, very commodiously situated for aquation by reason of the nearness of the river Teme."

Leintwardine is now famous for the abundance and size of the grayling, and in former days, when "grasshoppering" was allowed there, I have taken many a basketful from the gravelly Teme. This fish (Thymaallus vulgaris) is somewhat uncommon in England, but abounds in the Black Forest in Germany. It is said to have been called "the flower of fishes" by St. Ambrose, in whose time it was known as the Umber (umbra, a shadow), from its habit of turning and glancing when rising at insects. Giraldus writes: "The Wye alone produces the fish called Umber, the praise of which is celebrated in the works of Ambrosius, as being found in great numbers in the rivers near Milan. What," says he, "is more beautiful to behold, more agreeable to smell, or pleasant to taste?"

At Aymestry, the limestone is seen on both banks of the river Lugg. Pentamerus Knightii and Lingula Lewisii are very fine here, and a good collection of the typical fossils of the neighbourhood is in the possession of Mrs. Lewis of Aymestry Court. The Garden House quarries at Aymestry afford excellent opportunities for examining the Lower Ludlow beds, and from them the Rev. T. T. Lewis obtained many specimens of the fossils figured in the "Silurian System." The rocks on the left bank of the river Lugg, between Aymestry and Deerfold Chase, appertain to this series of deposits. When investigating the Aymestry district, the travelling geologist should sojourn at the little inn of "Mortimer's Cross." It is close to the battle-field where on Candlemas Eve, 1461, Edward IV., then Earl of March, defeated the forces of Henry VI. under Jasper, Earl of Pembroke. Jasper's father, Owen Tudor (who married Catherine of France, widow of Henry V.), was here taken prisoner, and was afterwards beheaded at Hereford, and buried at the Grey Friars. The site of the battle was Kingsland Field. At the angle of the roads is a stone pedestal erected to perpetuate the memory of "the obstinate, bloody, and decisive battle," whereof Speed relates that "before the battail was strok, appeared visibly in the firmament three sunnes, which after a while joined together, and became as before; for which cause Edward afterwards gave the sunne in his full brightness for his badge and cognizance."

Croft Ambrey is a hill of Aymestry limestone, on which is a camp, believed to have been British, and it is another of the many localities selected by antiquarians as the scene of the last struggle of Caractacus.

In the neighbourhood of Presteign the subdividing limestone is no longer seen, and the only way of separating the Lower from the Upper Ludlow strata, is by the groups of typical fossils; the Lower rocks also are rather more argillaceous than the Upper beds.

In the Malvern district Professor Phillips assigns a thickness to the Lower Ludlow rocks of 750 feet. Near Malvern they occupy the space between Colwall Copse and Brockhill, and below Mathon Lodge by Bank Farm. Near Eastnor their position is well defined by the valley of Ockeridge. The Farm of Ockeridge is built upon the denuded shales, and is situated between the Wenlock limestone of the Ridgeway and the Aymestry rock of Chances Pitch, down which the Malvern road passes towards Ledbury. The Ockeridge valley affords characteristic Lower Ludlow fossils. Examples may be seen in the Museum of the Malvern Field Club, at Malvern, and among them the Phragmoceras pyriforme and the Orthoceras Ludense. The same rock was exposed in the Ledbury tunnel, from which excavations Dr. Grindrod obtained a magnificent specimen of the trumpet-shaped Lituite (L. Biddulphii). To the northward these shales run in a narrow strip, between the ridges, to Tunridge and Blackhouse Farm.

In the Ledbury district, the Aymestry rock is conspicuous by the high, long ridges which it presents to the eye of the geologist on the western border of the Silurian strata, as in the narrow crested hill which runs northwards from Ledbury Church by the Doghill turnpike, Bradlow Hill, and Frith Wood. The contortions of these strata are complicated, owing to undulations produced by great lateral pressure.

Near Great Malvern the Aymestry limestone may be studied at Hales End quarry, where it passes upwards into the Upper Ludlow shales, surmounted by the Bone bed; the Ledbury shales, or Passage rocks, being here faulted and thrown down.

The Upper Ludlow shales, with the Downton Passage beds, trend from Storridge on the north, to Ledbury on the south-west, and may be seen in contact with the Lower Old Red Sandstone in many localities, as at Lord's Wood, the western slope of Suckley Hills, Hales End Farm, Mathon Lodge, Brockhill, Frith Farm, and Dog Hill, near Ledbury. There is a good section at Hales End, exhibiting the passage from Lower Ludlow strata through the Aymestry rocks to the overlying Old Red Sandstone. Mr. J. W. Salter detected the Bone bed here, and describes it as being similar in almost all respects to that which occurs at Ludlow. It may be found behind the coach-house of Hales End House, on the south side of a small ravine opposite the great quarry. It contains many small spines of the little fish allied to the shark, Onchus Murchisoni. Similar strata have been observed at Brockhill, near Mathon, and there too the Bone bed was discovered by the late Mr. Dyson.

The old border town of Ledbury stands partly on the Passage rocks and Lower Old Red Sandstone, and partly on the ancient river drifts of the Leddon, which have yielded the remains of the Rhinoceros and Mammoth, while on the one side it is flanked by wooded Silurian hills, and on the other by the Old Red of Wall Hills Camp.

The Lower Ludlow series may be seen near the town in the little valley which runs between the Doghill and the Wenlock quarries to the south; also below West Bank, where numerous fossils, among them some beautiful Orthonotas and other bivalves, such as Cardiolæ and Modiolopsis, may be obtained from the detritus of the railway shaft. At the section at Doghill the dip of the Aymestry rock is nearly perpendicular; this is also the case at the spot where the Aymestry beds are traversed by the Ledbury tunnel. A few dwarfed specimens of the characteristic Pentamerus Knightii were collected from these beds by Henry Brooks of Ledbury, but this fossil is very rare in the neighbourhood of the Malvern Hills. Lingula Lewisii abounds at Ledbury, and occurs in nodules, which, when split open, exhibit the enclosed

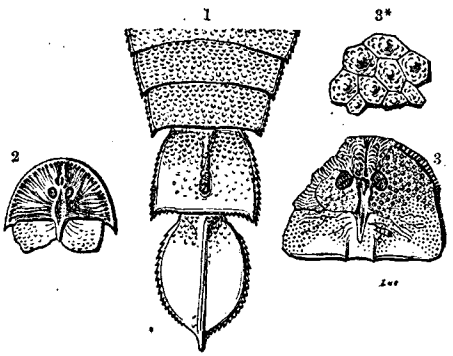
Lingula, shining, and of a nut-brown hue. Lingula Symondsii is more characteristic of the Lower Ludlow shales, and is rarely met with in the limestone. There are sections in the Upper Ludlow shales at Frith Farm, and near the Doghill turnpike, north of Ledbury; the Downton sandstone, however, is not exposed, neither has the Bone bed been detected here.

The Ledbury, or Passage rocks, which connect the Upper Ludlow shales with the basement beds of the Old Red Sandstone epoch, were well exposed during the excavation of the Ledbury tunnel on the Worcester and Hereford railway.* Commencing in the tunnel with the Aymestry rocks, which yielded small specimens of Pentamerus Knightii, there followed a considerable thickness of Upper Ludlow shale, with the typical fossils Chonetes lata, Discina rugata, and Serpulites longissimus, succeeded by yellow Downton beds, but poorly developed, with the typical Lingula cornea. After the Downton beds came a series of red and mottled marls and sandy beds which yielded a large Lingula and fragments of a fish, either Pteraspis, or Cephalaspis. A band of grey shale and thin grit surmounted these marls, &c., and furnished the head of Cephalaspis Murchisoni (also found in the Passage beds of Ludlow), and a portion of a Pterygotus. I believe the grey marl, and bluish grey rocks (Auchenaspis beds), with the purple shales below, to be the equivalents of the liver-coloured and grey rocks of Ludlow, which also contain the little Cephalaspidean fish, the Auchenaspis Salteri of Egerton. These same Auchenaspis grits also afforded portions of other fossil fishes, Plectrodus, Scaphaspis, and Onchus, as well as the crustacean Pterygotus, and a large Lingula. At Ledbury the Auchenaspis was so abundant that as many as four heads were found upon a small slab, a foot in diameter. The tail and body of this fish are as yet unknown. The Auchenaspis grits at Ledbury proved to be fifteen feet thick, and pass upwards conformably into a series of red marls with yellowish grey and pink sandstone, which contains portions of the plates both of

* See Paper by the Author, Quart. Jour. Geol. Soc., May, 1860.

Pteraspis and Cephalaspis. These fossil fishes are now in the Museum of the Earl of Enniskillen.

CRUSTACEAN AND FISHES FROM THE PASSAGE BEDS.



1, Pterygotus Ludensis, Salter; the caudal portion, much reduced in size. 2, Auchenaspis Salteri, Egerton; head-shield. 3, Cephalaspis? ornatus, Egerton; (an imperfect head-shield; half the natural size.) 3*, Portion of Fig. 3, magnified.

Camden mentions Ledbury as "a town of note which Edwin the Saxon, a man of great power, gave to the church of Hereford, being persuaded that he was cured of the palsy by the intercession of St. Ethelbert." And there is little doubt that "the military works on the neighbour hill" which he alludes to, are the intrenchments on Wall Hills, about a mile and a half distant towards the north-west.*

In the centre of the town is a curious old Market House, which stands on the site of a still older building where markets were held in the time of King Stephen; and nearly opposite is the Hospital of St. Catherine, founded in memory of a religious lady of the days of Edward the Second. Of St. Catherine there is a legend that she had "a maid called Mabel, and not being fixed in any settled place, she had a revelation that she should not set up her rest till she came to a town where the bells should ring of themselves. She and

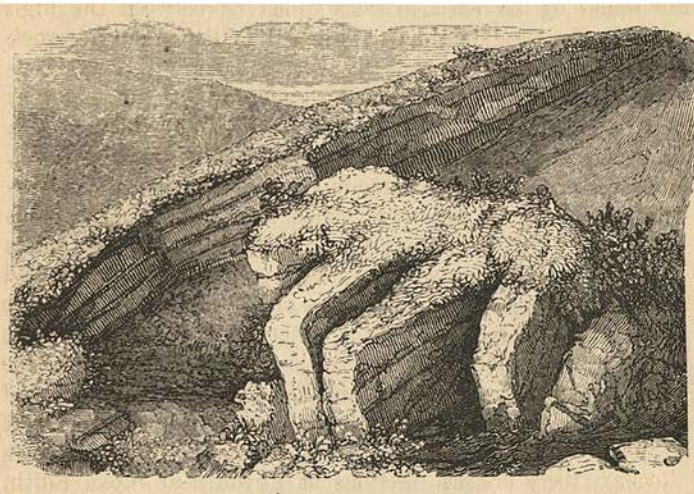
* Gibson's Camden, p. 578.

her maid coming near Ledbury, heard the bells ring, though the church doors were shut and no ringers there. Here then she determined to spend the remainder of her days, and built an Hermitage, living on herbs and sometimes on milk." *

In the Woolhope country it is easy to trace the Lower Ludlow shales by the denuded vales which lie between the high grounds of Stoke Edith Park, formed by the Aymestry rock and Upper Ludlow deposits, and by the bold outline of Wenlock limestone which at the Dormington quarries, and other localities, separates the valleys of Lower Ludlow strata from the Wenlock shales. The Lower Ludlow graptolite (G. Ludensis) occurs in considerable abundance on the south-western slope of the ridge which runs from Adam's rocks (Backbury Hill) towards Stoke Edith Park. These shales should also be examined at a point between Marcle Hill and Pilliard's Barn. The high ranges of hill ground which circle round this celebrated "valley of elevation," and denudation, are occupied by Aymestry rock, save in those instances where the outline is broken, as at Mordiford, Fownhope, Soller's Hope, and Lindels. The best points from which to see its position are at Oldbury Camp, Seager Hill and Backbury Camp (Adam's Rocks); there are also sections at Pirton near Stoke Edith, and near the village of Fownhope. In this district the typical fossil of the Aymestry limestone is Pentamerus galeatus, which appears to take the place of P. Knightii; it occurs in abundance at Niagara in the hard limestone below the Falls; the well-marked rotund brachiopod, Rhynconella Wilsoni, is also plentiful in the Upper Ludlow shales. When this rock was quarried some years ago at Bodenham, in the parish of Marcle at the south end of the Woolhope upcast, I obtained several specimens of Pentamerus Knightii, but they were dwarfed and but little larger than the P. galeatus. My friend the Rev. P. B. Brodie, so well known for his researches among fossil insects, describes the Passage beds of Woolhope ("Quart. Jour. Geol. Soc." Aug. 1871) at Putley and Pirton, where he succeeded in obtaining Pterygotus Banksii, three species of Eurypterus, and

* Gough's Camden, vol. ii. p. 456.

an almost entire specimen of a new species of Eurypterus, named E. Brodiei by Mr. Woodward. Besides these crustaceans he found fossil plants somewhat similar to the Psilophyton described by Dr. Dawson as occurring in strata of nearly the same age in America. I have found remains



THE PALMER'S CAIRN LANDSLIP.
(Drawn by the late Rev. W. R. Evans.)

of Scaphaspis in these Woolhope Passage beds. At Pirton these Passage beds may be seen resting directly on Upper Ludlow rocks full of Chonetes lata, but the higher Auchenaspis beds are denuded along the Woolhope country. Schucknall Hill, two miles eastward of the Dormington side of the Woolhope valley, is an interesting wedge of Aymestry rock, faulted through the Lower Old Red, and presenting an edge of broken-off strata on the western escarpment. The large quarry furnishes many typical fossils, such as Chonetes lata, Rhynconella Wilsoni, &c.

There are several large landslips in the Upper Ludlow rocks around the Woolhope district. The only records which

remain of the slip which took place at Adam's Rocks on the south side of Backbury Camp are the legends of the country people, who, in our schooldays, attributed the occurrence to the earthquake at the Crucifixion. The "Wonder" near Putley was a landslip which happened in the year 1575, and was also attributed to an earthquake. It is recorded in Drayton's "Polyolbion," and is thus described by Camden: "Near the conflux of the Lugg and the Wye, eastward, a Hill, which they call Marcley Hill, in the year 1575 roused itself up, as it were, out of a sleep, and for three days together shoving its prodigious body forward, with a horrible roaring noise, and overturning all that stood in its way, advanced itself (to the great astonishment of the beholders,) to a higher station: by that kind of Earthquake, I suppose, which the Naturalists call Brasmatia." (Gibson's Camden, p. 578.)

A few years ago, another great slip occurred between Dormington and Stoke Edith. Shortly afterwards I visited the spot with Sir Charles Lyell, then on a tour through Siluria, and he was particularly struck with the numbers of the typical fossil, Pentamerus galeatus, which lay scattered about in profusion. The cause of these great landslips may be referred to the jointed structure of the rocks, the steepness of the dip of the beds, and the percolation of much rain down the joints.

The Passage beds of Bodenham, five miles west of Ledbury, on the Ross road, furnished the first determined specimens of the Silurian club moss, Lycopodites. They were described by Dr. Hooker as being undoubtedly the seed-vessels of a terrestrial plant, and as throughout all the vast thickness of the lower rocks no other terrestrial vegetable remains have as yet been discovered, these little pellets still hold the position of the earliest known relics of land vegetation. The Bodenham strata belong to that mass of Upper Silurian rocks, which have been elevated through the Old Red Sandstone of Herefordshire by the great Woolhope upheaval. It would be tedious to give the various sections which occur between Fownhope and Mordiford on the north, four miles from

Hereford, and at Gorseley on the south, two miles west of Newent. At the latter locality they are seen near a large pool, overlying the Ludlow rocks, and contain remains of Pterygotus. They are also largely quarried at Clifford's Mine, near Newent wood, and furnish Lingula cornea.

Around May Hill the Aymestry rock and the Lower Ludlow beds appear to have much thinned out. A thin impure limestone, worked at Gorseley common, north of May Hill, is the representative of the Aymestry beds, and affords specimens of Pentamerus galeatus. The workmen call these fossils "*gold nuts*," as in some instances this shell, when broken, contained in the septa the needle-like spiculæ of sulphuret of nickel. The Upper Ludlow rocks are exposed east of the Longhope station, where they dip at a high angle under the Old Red Sandstone, and contain many typical fossils. This district is full of faults, especially above the line of the brook. These rocks may be seen in Linton wood, and in several other localities in the neighbourhood. Mr. Hugh Strickland detected the Bone bed at the south end of May Hill in the railway cutting near Flaxley. There, also, remains of fish and crustaceans have been discovered, and I have found amongst them portions of the plates of Pteraspis. Again, at Pyrton passage on the Severn below Newnham, Professor Phillips detected portions of the Bone bed cropping out at low water from beneath the river mud. The elevated Ludlow rocks may be observed near Pyrton passage Inn, from whence the upheaved Silurians range southwards to a distance of nine miles, towards Berkeley and Tortworth. Rhynconella navicula characterizes the Upper Ludlow rocks of this district.

The Silurian district of Usk is, like that of Woolhope, elevated through Old Red rocks, but the hills and vales are irregular, and differ much from that peculiar amphitheatre. The Usk hills range north and south, and the lowest beds exposed are the Wenlock shales, which near Cilfigan Park and Prescoed become sandstone rock, so like Caradoc sandstone as to deceive Sir R. Murchison and the Geological Surveyors. The Aymestry series is represented by calcareous bands which

occur at Llancago Hill, at Hill Barn, and on the right bank of the Usk river at Llanbadock, where the "blue stone" yields Pentamerus galeatus. Usk Castle across the river stands on Upper Ludlow rock overlaid by the Passage beds, and the river runs on a line of fault. The Downton rocks occur at Bettws near Trosta, and, if I read the section rightly, they are overlaid by masses of purple and grey grits, which surround Usk and rise into high ground. It is my impression that these rocks are thinly represented in the Ledbury tunnel, where they overlie the yellow Downton beds and underlie the Auchenaspis grits. The equivalent beds at Ledbury furnished a Lingula and the carbonaceous markings of plants. In the Usk district these beds also occur at Llandegfydd, &c. If these rocks at Usk prove what I suppose them to be, they belong to the *Downton series* and not to the Old Red as marked in the maps. I am not aware that they have as yet furnished fossils.

The town of Usk is supposed to have been built on the site of a Roman station, the Burrium of the Itinerary of Antoninus. The castle dates from the time of Henry I. Archbishop Baldwin preached there in 1188, for Giraldus Cambrensis records that "at the castle of Usk a multitude of persons influenced by the Archbishop's sermon were signed with the cross." King Richard III. was born here, but in the time of Elizabeth it was in a very dilapidated state, for the poet Churchyard describes it as "torne with wether's blast and time that wears all out." Around Usk are the remains of ancient camps and fortifications, the principal of which is Craig-y-Garcyd, two miles to the north-west.

In the south of Pembrokeshire, these strata are brought to the surface in the St. Marloes district, and I saw some characteristic fossils in the possession of the Rev. Mr. Sanders, Vicar of St. Ishmael's, which had been found close to his picturesque Church and Vicarage.

In the district of the Abberley Hills the Wenlock shales are but slightly exposed in the valley between Ridge Hill (700 feet in height) and Fetlocks Farm, while the Lower Ludlow

series occur at Hole Farm, half a mile south-west of Woodbury Hill. The Aymestry rock appears in well marked ridges, as around Ledbury, and strikes from Hill End, west of Martley, to the west of the Hundred House. Pentamerus Knightii has been found at Hole Farm. The Upper Ludlow rocks and Passage beds are flanked by Old Red Sandstone on the west at Hole Farm, and at the end of Wallsgrove Hill (near 900 feet in height), where numerous typical fossils occur. There is also a quarry at the northern extremity of Abberley Hill, where these shales are seen dipping at a high angle and resting against the Aymestry limestone, which constitutes the characteristic rock ridges of this district. There also Mr. Roberts discovered the equivalents of the Bone bed.

At Ankerdine near Knightsford Bridge is a quarry where these rocks may be examined; the same strata are also exposed on the northern flank of the hill, faulted against the Old Red Sandstone on the west and the Permian strata on the east.

At Trimpley, north-west of Kidderminster, the Passage beds are elevated to the surface by an upcast. Mr. George Roberts, formerly clerk to the Geological Society, conducted me to this locality some years ago, and showed me many interesting fossils he had collected here. They included Parka decipiens, (the spawn of the Pterygotus), the tail spines of the shrimp-like crustacean Ceratiocaris, two species of the ganoid fish Pteraspis or Scaphaspis, and also a Cephalaspis.

At Linley, Salop, four miles north of Bridgenorth, Mr. John Randall, F.G.S., discovered a series of sections ranging from the upper Coal measures to the Aymestry rock, which, in places, forms the bed of the Linley Brook. The Upper Ludlow rocks and Passage beds are also exposed, the latter furnishing the remains of the fishes Plectrodus and Onchus. Lingulæ occur here with remains of plants, while in the Upper Ludlow rock that typical annelid Serpulites longissimus appears at the base of the section.*

There is an isolated upthrow of Upper Ludlow rock through

* See Paper by Roberts and Randall, with section (Quarterly Journal Geological Society, August, 1863).

the overlying sandstone at Neen Sollers, on the line of the Cleobury and Tenbury railway. The Passage beds only are seen in the cutting, but hills of Upper Ludlow rock rise on the left hand and on the right. The members of the Malvern Field Club visited this section during the summer of 1865. We detected the Lingula of the Downton Sandstone and portions of the Bone bed in the railway section.

On this occasion, our head quarters were at Cleobury Mortimer, a curious old town, and the birth-place of Robert Langland, who wrote the remarkable poem "The Visions of Piers Plowman," in 1362. The author supposes that he beholds a series of visions while asleep on the Malvern Hills. It is a clever allegorical description by a Wickliffite of the vices of the clergy and of the times.

ORGANIC REMAINS OF THE UPPER SILURIANS.

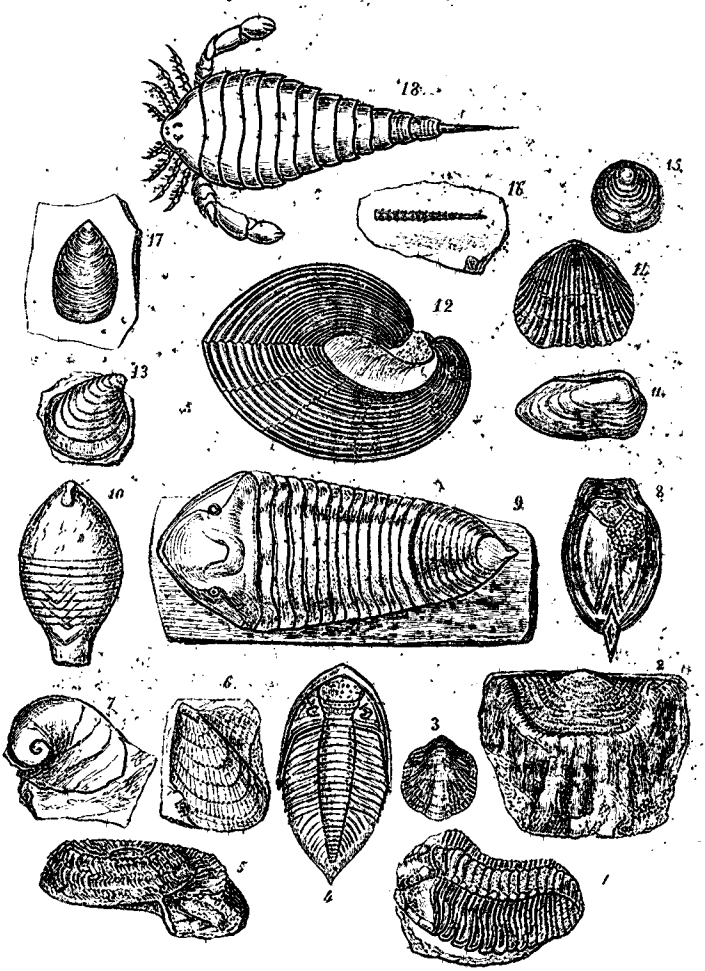
The geological history of the Upper Silurian formation is characterized by the evidence we find of a warm climate in the remains of marine animals and in the abundance of corals. We detect no remains of freshwater lakes or rivers, or freshwater animals, and no tokens of Silurian land, until, in the uppermost beds, we find the first known representative of a land plant in the small club moss, Lycopodites. Until we arrive at higher deposits, the range of animal life is much the same as that of the Lower Silurians.

Among the Cephalopoda (the highest forms of mollusca) are various genera, Lituites, Cyrtoceras, Orthoceras, Phragmoceras, Ascoceras, and Oncoceras. Conularia and Theca are tolerably abundant, and belong to the wing-footed Mollusks, or Pteropods.

The Gasteropodous shells, allied to the existing sea shells Haliotis or Ormer, Turbo, Turritella, and Pyramidella, are represented by the Silurian forms of Pleurotomaria, Murchisonia, Acroculia, Euomphalus, and Loxonema.

The Conchifers, or Bivalves, have increased considerably in numbers and species, and furnish several species of Pterinea and Cardiolæ, shells allied to the living Avicula. Modiolopsis and Orthonota belong to the family of mussels, Modiola and

PLATE IV.



1. Calymene Blumenbachii.
2. Strophomena depressa.
3. Atrypa reticularis.
4. Phacops caudatus.
5. Euomphalus rugosus.
6. Pterinea Sowerbyi.
7. Acroculia haliotis.
8. Ptoraspis.
9. Homalonotus Delphino-cephalus.
10. Phragmoceras pyriforme.
11. Orthonota impressa.
12. Pentamerus Knightii.
13. Cardiola fibrosa.
14. Rhynchonella nucula.
15. Discina striata.
16. Tentaculites ornatus.
17. Lingula Symondsii.
18. Eurypterus Brodei.

[Page 210.

Cucullella to the Arcaceæ, while the Anatinidæ are represented by Grammysia. Brachiopoda are very abundant, and although Orthis becomes rare, we find Chonetes and Athyris added to the Upper Silurian forms. The Bryozoa are represented by Ptilodictya, which is common in the Wenlock limestone, and Fenestella.

Graptolites become scarce as regards species, as in the Upper Silurians only one or perhaps two species are found, and not one is known above the Ludlow rocks.

Corals are abundant, the most prominent forms being Favosites, Heliolites, Cœnites, and Halysites.

Several species of Cystideæ are known, and many beautiful Crinoideæ.

Star-fish abound in the Lower Ludlow strata.

Several new genera of Trilobites make their appearance, and a new form of Crustacean in the Eurypterus, which differed from the Pterygotus in having its eyes fixed on the shield instead of on one side.

Lastly, Fish are known to have existed in the Lower Ludlow seas, and several species are now registered from the Upper Ludlow and Passage rocks, some of them being believed to be allied to the Sharks, and others to existing Ganoids.

CHAPTER VII.

OLD RED SANDSTONE.

Classification of Old Red Strata — Deposition of — Outliers of Old Red — Fossil Fishes of the Old Red—Leominster—Hereford, Historic Records of —The White Cross—Cornstones of Ewyas Harold—Rowlestone Beds— Fossils of—Abbey Dore—John of Kent—Abergavenny Castle—Scyrrid Fawr — Lord Cobham — Llanthony Abbey—Foundation of — Gadir — Brownstones of the—Onchus Major, from Cornstones of Cusop—Hay— Isle of Skomer, Birds of the—Brecon—Church of St. Almedha—Brecknockshire Beacons — Llynsavaddon — Old Red Conglomerates — Daren Sandstones — Farlow Sandstones — Pterichthys — Ross — Sections near Tenby—Manorbeer Castle—Organic Remains of Old Red Sandstone.

Upper Old Red Sandstone.	The Upper beds are Red Beds interstratified with yellowish grey sandstones, and below are Old Red conglomerates and red marls.	*Fish.*	Pterichthys. Holoptychius.
		Mollusca.	Conularia at the Clee Hills.
			Land plants.
Brownstone Series.	Red marls overlying chocolate-coloured sandstones, passing downwards into reddish and grey sandstones and marls, with thin cornstones.	No fossils known in these strata, but fragments of Pteraspis and Cephalaspis.	
Cornstone Series and Lower Old Red, with interbedded Sandstones.	The Upper beds, where not denuded, are grey and greenish sandstones, with remains of plants, as at Rowlstone, near Abergavenny, and Cusop, near Hay. Below are impure limestone concretions, named cornstones, interstratified with reddish and grey sandstones, red marls, &c.	*Crustacea.*	Stylonurus. Pterygotus. Præarcturus.
		Plants.	Probably Fucoids.
		Fish.	Cephalaspis. Didymaspis. Zenaspis. Scaphaspis. Pteraspis. Cyathaspis. Onchus.

It will be understood from what has been already stated, that there is no visible break between the Upper Silurian rocks and the overlying Passage beds. As observed in the Ledbury tunnel and other localities, there is no unconformability; but the rocks of the Silurians pass into those of the

SILURIAN ROCKS OF MARLOES BAY, DIPPING UNDER THE OLD RED SANDSTONE OF HOOK POINT, PEMBROKESHIRE.

Ledbury shales by an easy transition, only marked by a decided change in colour. The red marls that commence with the Passage beds and overlie all the Ludlow rocks cannot be mistaken by the most unpractised eye.

Sir Charles Lyell, in his last edition of the "Elements of Geology," has placed the Ledbury shales or Passage rocks at the base of the Old Red group. I have not followed this grouping, because, above the Ledbury shales, whether at Ledbury, Cradley, Ludlow, or Kington, there appears to be a decided break and unconformability in the strata, along which fault the river Leddon at Ledbury, the Teme at Ludlow, and the Arrow at Kington take their flow. Again, in the Ledbury shales (Passage beds), Silurian fossils undoubtedly occur, intermingled with forms of fishes closely allied to those found in the Lower Old Red. But no geologist has yet detected a single *species* which ascends from the Ledbury shales into the

Old Red rocks above the break alluded to. This appears to indicate a decided unconformability at the base of the Ledbury shales, and, if this be the case, it would be better to place the base of the Old Red proper above the break, than in the middle of a series of strata which are absolutely conformable, and where fossils intermingle.

The Old Red Sandstone received this name originally, because in Herefordshire and in Scotland these strata are covered up by the Carboniferous groups; whereas the New Red Sandstone was deposited above the Carboniferous rocks. The term Devonian was afterwards applied by Murchison and Sedgwick to the whole series of Old Red strata, but this term nevertheless is more generally applied to the foreign representatives of the Old Red group, and the ancient nomenclature Old Red is not likely to be changed to Devonian as regards the rocks of Herefordshire and Monmouthshire, or the far-famed Scotch strata of Hugh Miller.

Objections have been raised against erecting an "Old Red System" or a "Devonian age," as a distinct geological formation, and certain geologists have proposed to link this series of rocks to the Silurian group; while others propose that they should be considered as belonging to the Lower Carboniferous rocks. There can be little doubt however that these strata mark a new epoch in the progress and development of animal life, and thus stand apart as a system of geological history from the Silurian groups; while in the total absence of many of the fossil remains typical of the Carboniferous rocks, it seems advisable to draw a line of division between this epoch on the one hand and the Silurian epoch on the other.

The change from the grey rocks of the Silurian strata to the red marls and grey and red sandstones of the overlying deposits, is hardly more striking than is the disappearance of the numerous fossils which are so characteristic of the Silurian epoch. The change is probably owing to oscillations of the land, changes of the sea-level, the flow of currents, and the deposition of strata, all of which would affect and often exterminate the inhabitants of the seas. The period of the Bone

bed and Upper Ludlow shales appears to have been one of shallow water and litoral conditions, judging from the number of crustaceans found imbedded therein with remains also of land plants. The Old Red rocks would seem to have been deposited on a sinking area and under conditions not favourable to the growth of corals and the life of marine mollusca.

It has been advocated by Mr. Godwin Austen, and since by Prof. Ramsay, that the Old Red of Scotland and Siluria may have been deposited in great freshwater lakes, but it is difficult to correlate this theory with the occurrence of Old Red fish, such as Coccosteus, in the rocks of Germany, and great numbers of Pteraspis in Devonshire, where they are associated with true Devonian marine shells; or with the presence of crustaceans in the Cornstones of Herefordshire, as these crustaceans are probably marine, and species occur in Silurian strata associated with Lingula, and other marine

CRUSTACEAN FROM THE OLD RED OF HEREFORDSHIRE.

Stylonurus Symondsii (Eurypterus, Salter, Quart. Journ. Geol. Soc. vol. xv. pl. 10, fig. 1); from Rowlestone, south of the Hay, Brecknockshire. The cephalic shield of a Crustacean allied to Pterygotus. For figures of this and other species of Stylonurus, see Mr. H. Woodward's paper in the Quart. Journ. Geol. Soc. vol. xxi. p. 482.

shells. Should it be established that the Stylonurus is of marine, and not of fresh-water origin, we must regard the fresh-water theory of the Old Red of Herefordshire as untenable; for although we find fresh-water shells and fishes drifted into marine depositions by the agency of rivers, it would be difficult to account for any agency through which marine lobsters should be transported into a fresh-water lake.

LOWER OLD RED SANDSTONE.

In North Wales the Old Red Sandstone is but very slightly developed. When it occurs it appears to belong to the upper series of these strata, as the beds directly underlie the Carboniferous limestone. In Anglesea the Old Red appears between the mountain limestone of Lligwy and Moelfre, and the volcanic rock of Parys Mountain, and also in Dulas Bay, from whence it may be traced in a south-eastern direction to Llangefni, in the vale of Cefni. Near the small town of Abergele is a thick bed of Old Red Conglomerate, made up of fragments of Silurian and Igneous rocks; it rests unconformably upon Wenlock rocks, near Abergele, but it is conformable to the overlying mountain limestone. It strikes southwards, by Ruthin, with the limestone, and appears to the north by Llangollen. The fields lying between the Eglwsey rocks and the hills bounding the Valle Crucis, or Valley of the Cross, are red, with its detritus. At Llanymynech, south of Oswestry, the conglomerate rests upon fossiliferous Bala beds.

In studying the Old Red Sandstone of Siluria, the geologist should examine the grand exhibition of strata, commencing with the Lower series of beds as seen succeeding the Silurian rocks, then follow up the middle group of beds as developed in the hills of central Herefordshire and Monmouthshire; and finally pursue the investigation of the Upper rocks in the lofty hills of the Black Mountains, and in the Vans of Brecon and Carmarthen, which rise in the Brecon Mountains to the height of 2860 feet above the sea.

The most northern district of Siluria where we know of the existence of the Lower Old Red in situ, is in the Forest of Hayes, in the Long Mountain, where a considerable outlier of Old Red deposits rests on Upper Ludlow strata with the typical fossils. This detached outlier, with its remains of Pteraspis and Scaphaspis, is especially interesting to the physical geologist, so completely does it exhibit how the masses that once connected it with the main formation have been removed by denudation; and it is here evident that the Lower Old Red of the Long

Mountain district is a remnant of a large area of the same strata which was formerly continuous with that of the Ludlow country and Clun Forest, before the Silurian rocks had been upheaved and dislocated.

Clun Forest, on the borders of Shropshire, between Montgomery and Knighton, is another great mass of detached Lower Old Red, which overlies the Upper Silurians, and occupies a district of nearly one hundred square miles. There are red beds near Felindre, which contain the characteristic fossils of the Passage beds, and these are again overlaid above Newcastle, and near Beltws, by Lower Old Red sandstones and marls, with plates of the characteristic fishes. This country also offers a study for the physical geologist who enters into the study of *outliers*, and the evidences of elevation and denudation, for around the town of Knighton are four outliers of Lower Old Red, separated by Silurian hill masses. Thus we have the Clun outlier, and that of Beltws-y-Cryn, with two smaller patches west of the Teme, and the outlier north of Knighton. Near Presteign we find a large mass of Lower Old Red running northwards, west of Brampton Bryan. These strata, like those of Clun Forest, are elevated with the Silurian hills. South of Presteign another small patch of great interest indicates the former continuity of the Lower Old Red over this country. It is called Lower Radnor Wood, and lies west of the upcast of Woolhope limestone by the Stanner trap, within a mile of Presteign. It is impossible to examine all these isolated patches of a great formation without feeling positive that the strata were once continuous with those of Clun Forest, and again of the Hayes Forest on the Long Mountain.

We have already alluded to the beautiful scenery and interesting geology of the neighbourhood of Old Radnor, and we would now direct attention to the singular remnants of Lower Old Red, which in this district lie caught up among Silurian and Trap rocks. One patch runs from Weighthall, south of Old Radnor, for three or four miles, and another occurs at Llanhowel, in the parish of Gladestry. Again, nowhere in this neighbourhood are the relations of the Upper Ludlow shales

with the Passage beds better shown than about Rain's Castle, beyond Glasbury; but the difficulty here, as elsewhere, is to shew a conformable passage upwards into the Old Red proper above the Passage rocks, which in this country are of considerable thickness.

If a geologist in search of rock sections and fossils, and who disdains not antiquarian and legendary lore, arrives perchance at the little village of Glasewm, in this border land, let him turn into the church, where in the days of Giraldus there was "a portable bell, endowed with great virtues, called Banyn, and said to belong to St. David. A certain woman secretly conveyed this bell to her husband (who was confined in the Castle of Raidergwy, near Warthrenion, which Rhys, son of Gruffydh, had lately built) for the purpose of his deliverance. The keepers of the castle not only refused to liberate him for this consideration, but seized and detained the bell, and in the same night, by divine vengeance, the whole town, except the wall in which the bell hung, was consumed by fire."

In the Wenlock country the Lower Old Red beds fringe the Upper Ludlow rocks, and run southwards by Holgate, down Corvedale to Ludlow. It was at Whitbach, about three miles north-east of Ludlow, that Dr. Lloyd first discovered the shield of a ganoid fish, which is still in the Ludlow Museum, and bears the name of Scaphaspis Lloydii. The strata are flagstones, and are overlaid by a band of thin Cornstones with scales of the Pteraspis, similar to those obtained by Mr. Ray Lankester at Cradley. I have frequently examined the Whitbach quarries, and I believe that they lie at the base of the Old Red proper in the Ludlow country. They yielded a specimen of a nearly perfect Cephalaspis Lyellii, to the hammer of Mr. Marston of Ludlow; and here, and at Bouldon, the searcher for fossils may also obtain the Cephalaspidean fish, Zenaspis Salweyi, with Scaphaspis Lloydii, and the long-snouted Pteraspis Cronchii, as well as fish tracks, and egg packets of Pterygotus. The Zenaspis Salweyi is allowed to be a well defined species by Messrs. Ray Lankester and Powrie. It was first discovered in the Old Red Cornstones at Hinston, and Acton Beauchamp,

near Bromyard, by my friend Mr. Humphrey Salwey of Ludlow, who has also detected it in Corvedale.

In his great work, "Recherches sur les Poissons Fossiles," (1835) Prof. Agassiz established the genus Cephalaspis to include four divisions of Devonian fishes, namely—C. Lyellii, C. rostratus, C. Lloydii, C. Lewisii.

Sir P. Egerton * described several new species related to C. Lyellii, viz.—C. Murchisonii, C. Salweyi, C. ornatus, and a new genus, Auchenaspis, which had a distinct neck-plate. Pteraspis, supposed by Dr. Kner to be the internal shell of a Cephalopod allied to Sepia, was shown by Prof. Huxley to be a fish.† He says "No one can, I think, hesitate in placing Pteraspis among fishes." So far from its structure having no parallel among fishes, it has absolutely no parallel in any other division of the animal kingdom. I have never seen any Molluscan or Crustacean structure with which it could for one moment be confounded." Pteraspis is closely allied to Cephalaspis in its structure, and Prof. Huxley believes that all the Cephalaspidean fishes are related to the existing Callichthys and Loricaria (Siluroid fishes) on one hand, and Scapirhynchus and Spatularia (Chrondrostean Ganoids) on the other.

Mr. Ray Lankester, in his monograph ‡ "On the Fishes of the Old Red Sandstone of Great Britain," divides the Cephalaspidæ into two sections, Heterostraci and Osteostraci. The reasons upon which the division is based, are derived from the structure of the Cephalic shields; the terms meaning that the Heterostraci possess a shell or dermal plate of a structure differing (ἕτερος = of another kind, and ὄστρακον = a shell, or dermal bone) from that of the Osteostraci (ὀστεον = a bone) which possess true bony structure in their plates or shields, as Cephalaspis Lyellii; the division may be as follows :—

Heterostracon Cephalaspidæ.....	Scaphaspis, Cyathaspis, Pteraspis.	Osteostracon Cephalaspidæ	Cephalaspis, Auchenaspis, Didymaspis.

* Quart. Journ. Geol. Soc., 1857.

† Memoirs of the Geol. Survey of Great Britain, Dec. 10, p. 38.

‡ Palæontogr. Soc. vol. xxi.

In the same monograph Mr. Ray Lankester considers it necessary to divide the Pteraspidean fishes into the genera Scaphaspis, Cyathaspis, and Pteraspis; and the genus Scaphaspis includes the species Lloydii and truncatus, &c., with a simple ovate shield. Mr. Lankester mentions an interesting fact with regard to the original type specimen of the genus Pteraspis of Dr. Kner, which he saw at Vienna in 1870. "A form like Pteraspis rostratus (C. rostratus of Sil. System) is present in one of the blocks; and in the block with Kner's figured specimen there are marine shells. An Orthoceras is lying almost against the fish shield, which is very perfect, and there are two Lamellibranchs in close proximity. We must not therefore conclude from the Cornstones and Scotch beds that the Cephalaspidæ were exclusively lacustrine or fluviatile.' * Kner's original specimen is exceedingly like Scaphaspis Lloydii.

Pteraspis, Cyathaspis and Scaphaspis are distinguished by the following characteristics :—

		Species.
Pteraspis	Shield composed of seven anchylosed but *distinct* pieces or plates, with a posterior spine.	Pteraspis rostratus, Pt. Crouchii, Salter MS.
Cyathaspis	Shield composed of four distinct pieces, spine reduced to a mere point.	Cy. Banksii, Huxley, and Salter. Cy. Symondsii, Lankester.
Scaphaspis	No distinct species recognisable in the large oval head-plate; spine represented by the acute termination of the disc.	Scaphaspis Lewisii, Ag. (Cephalaspis Lewisii, Sil. Syst.) Sc. Lloydii, Ag. Sc. Ludensis, Salter.

The genus Cephalaspis is divided by Mr. Lankester into three subgenera, Eucephalaspis, Hemicyclaspis, and Zenaspis.

Cephalaspidean fishes occur in Lower Ludlow beds—in Upper Ludlow Bone bed and shales—Downton rocks—Passage Red rocks at Ledbury and Ludlow—Lower Old Red and Middle Old Red of Breconshire. They have been found in

* Geol. Mag., vol. vii. p. 399, 1870.

Scotland, in Siluria, and Devonshire, in America, in Russia, in Galicia, and in the Eifel, in rocks intermediate between the Upper Silurians (inclusive) and the Lower Carboniferous.

In traversing the section from Whitbach to Hayton Sutton and Bouldon, we pass over successive beds of rocks; the Devil's Mouth, at the top of Hayton, yielding the plates of Scaphaspis and Pteraspis in considerable abundance. At Hopton Gate, two miles east of Hayton, that large form of Cephalaspis, Zenaspis Salweyi, was found by Mr. Harley. Mr. Harley thus describes the beautiful structure of the inner plate of the head of this fish. "It presents lacunæ and long branching caniculi precisely resembling those of human bone. Many of these are completely injected with a transparent blood-red material; and so beautifully are they thus displayed, that one ignorant of the structure of bone would be able to apprehend it by a glance at a minute part of this ancient fragment. So wonderfully indeed has Nature treasured up her secrets in this disentombed relic of a time so distant as to be incalculable, that she distinctly reveals in their minutest details the structure of canals not more than the one fifty thousandth of an inch in diameter, and such as to defy the skill of the anatomist to inject."

I do not consider the Clee Hill district near Ludlow at all a good neighbourhood for studying the physical relations of the Upper beds of the Lower Old Red, or those of the overlying Brownstones. In this country there is a great deal of faulting caused by the elevation of the Trap rocks through the Old Red and the Coal Measures, and this faulting throws down and dislocates the strata and obscures their physical positions. The Upper beds of the *Lower Old Red* are quarried above Bitterly Court, on the western side of the Titterstone Clee, and at Abdon and Ditton below the Brown Clee. I have never seen any fossils from these localities.

Near Tenbury, bold hills of the Middle beds of the Lower Old Red rise around the picturesque country of Stamford and Shelsley Wallsall. In Sir Thomas Winnington's grounds a large rock of travertine, called the "South stone rock,"

owes its origin to the percolation of water through Old Red Cornstone. The chancel of the church at Quatford, near Bridgenorth, appears to have been built of this travertine.

Leominster, in Herefordshire, is a place well adapted for pursuing investigations of the Lower Old Red. Leland describes the site of the town as "sumwhat lowe, and all the ground very neere about it is farre lower." These low lands are situated on those Lower marls and cornstones which are characterized by abundance of the remains of Cephalaspis Lyellii, and Scaphaspis Lloydii; the hills which rise from the plain consist of higher beds of sandstone and cornstone. The quarries at Leysters Pole, about four miles north-east of Leominster, and around Puddlestone contain many of the enamelled plates of Scaphaspis Lloydii, and P. rostratus, which, when first struck out from the rock glisten with purple and blue, the effect of phosphate of iron.

Ivington Camp, like all the hills in the immediate neighbourhood of Leominster, consists of cornstones, marls, and sandstones which overlie the Pteraspis-bearing beds of Puddlestone and Leysters Pole. Such are also the hills of Weobly, Dinedor, Moccas, and Tibberton, which stand out as rounded wooded hills on escarpments, and dip under the Upper Old Red strata of the Black Mountains. The fish remains in the Cornstones are very fragmentary.

Dinmore Hill between Hereford and Leominster is a good example of the succession of beds of the Lower Red epoch, capped by strata that pass into those which, for the sake of definition, we call the Middle Old Red.* Fish plates were found in the tunnel when it was being excavated, but I saw nothing new or worthy of remark. The geologist will not fail to observe the great expanse of the Lugg meadows, the rich pastures whereof are the effect of the silting of the existing river during a comparatively late geological period. A circumstance of considerable interest happened in this district not many months ago. My friend Mr. Curley, who was engaged in draining the Dinmore country, obtained from the silts of the Lugg very fine specimens of the horns of the Red

Deer and of the head of Bos primigenius. They were both disinterred at some distance from the bed of the present stream. He also obtained from the workmen a worn tooth of Rhinoceros tichorhinus, which he imagined came from the same site as the remains of the Deer and the Bos; but on our thoroughly investigating the localities together we were convinced that the Rhinoceros tooth came from the low level drifts and gravels on the Marden side of the Lugg, and not from the silts and alluvium of the existing river. Leland speaks of the view from Dinmore Hill "as a specula to see all the country about."

The neighbourhood of Leominster abounds with subjects of interest to the antiquarian. The church is remarkable on account of its relics of Norman architecture. Leland says that, as he saw it, "Yt is a grate likelihood that yt is the church that was afore the Conquest." It was much injured in the fire of 1700.

From the particulars recorded in the Doomesday book Leominster had become a place of considerable importance at the period of the Doomesday Survey. The town is spelt Leofminstre in Doomesday book. According to Leland "The antiquity of the towne is most famous by a Monastery of Nunnes that Merwaldus, Kinge of the Marches, built there." "Some say that the Nunnery was after in the Danes wars destroyed, and the certainty is known that the Abbey of Shaftesbury had rule at Lemster, and possessed much landes there, and sent part of the reliques of St. Edward the Martyr to be adored there."

Henry I. "annexed the laws of Lemster to his Abbey of Reading," and in the time of Henry II. we find Giraldus Cambrensis and the preachers of the Crusades passing through Leominster on their road to Hereford. Giraldus mentions this town under its ancient name of "Leonis Monasterium." But Camden says the British name was "Llan Lieni," signifying a church of nuns.

In the reign of King John, William de Breose, Lord of Brecknock, seized Weobly Castle, and marching on Leominster

burnt and plundered the town, together with the Priory and Church.

In the reign of Henry IV., Owen Glyndwr defeated the "Revolted Mortimer," on the banks of the river Arrow, (the "sweet Severn" of Shakespeare, being a mistake of the Poet) and confined him in a dungeon at Leominster. Ivington Camp is supposed to be the camp occupied by the Welsh chieftain after the battle of Shrewsbury, and from whence his army finally dispersed and fled. Many coins of the dates 1340 and 1390 were formerly found on the site of his camp.*

Hereford is *par excellence* the city of the Old Red, and few are the localities in Great Britain where the geologist, naturalist, and antiquarian can meet with more of interest than lies around this old city. Our notes upon the antiquities of Hereford are far too long to quote *in extenso* here; it must suffice to say that the precise era of its foundation is not known, and that wise men disagree as to the origin of its name. The most probable derivation is that given by Mr. Gough, in his "Additions to Camden's Britannia," viz., that the Britons called it Hên-fordd, or the Old Way, and from these words he believes the Saxons to have formed its present name, which in their language signifies the Ford of the Army.† It is probable that Hereford was founded soon after the decay of Magna Castra, or Kenchester, the Roman station a few miles to the westward. In Saxon times it became the capital of the Mercian kingdom, and possessed a church, which, according to Polydore Virgil, was very fine. "Templum quod Herefordiæ id temporis magnificum erat." This early church is supposed to have been constructed of wood, as Polydore Virgil records that the edifice, which was erected on the site of the present cathedral by King Offa, in expiation of the murder of Ethelbert, King of the East Angles, was built of stone, "lapidea structura:" apparently, observes Mr. Duncumb, "as a marked distinction from that which preceded it."

* See Price's Leominster, p. 25, and note.

† Additions to Camden's Britannia, vol. ii., p. 451.

Athelstan was at Hereford in the year 939, and made a treaty with the Cambrian chief and extorted an annual tribute.

During the reign of Edward the Confessor, about 1055, an army, under Gryffyth, King of Wales, and Algar, Earl of Chester, who married his daughter, ransacked Hereford, pillaged the cathedral, and killed Bishop Leofgar. According to Powell's "Chronicles of Wales," "the Britons returned home with manie worthie prisoners, great triumph, and rich spoiles, leaving nothing in the town but blood and ashes, and the walls razed to the ground." Edward the Confessor, who much preferred fasting to fighting, sent Harold (afterwards King Harold) to avenge the slaughter of his subjects at Hereford. Harold rebuilt, and probably laid the foundation of, the Castle, which was afterwards completed by the Normans, and he reduced the Welsh to such a state of submission that they put their King Gryffyth to death, and sent his head as a peace-offering to Harold.

After the Conquest King William held Hereford in his own demesne; and in 1141 it is recorded that Stephen attended divine service in the Cathedral on Whitsunday.

Henry III. and his gallant son Prince Edward were taken as prisoners to Hereford by Simon de Montfort, Earl of Leicester, and it was from Wide Marsh Common that the Prince, mounted on a swift horse, escaped to Dinmore Hill, and from thence to Wigmore Castle. During the Parliamentary wars Hereford held out so well for the King, under the gallant Barnabas Scudamore, that after the Restoration the city received a new charter, with the motto "Invictæ Fidelitatis Premium."

The antiquary should remember that Sutton Walls, east of Hereford, is the site of the Palace of Offa, King of the Mercians, and here Ethelbert was murdered by Quendreda, Offa's wife, while courting her daughter. According to all accounts the body of Ethelbert was first buried where the little church of Marden now stands, but was afterwards removed to Hereford. In his "Life of St. Ethelbert," Giraldus Cambrensis

mentions Sutton Walls under the name of "King's Sutton," and he also notices the ruins of a castle there. Leland speaks of the "notable ruines of some ancyent and great building sumtyme the mansion of King Offa, at such time as Kentchester stood, or els Hereford was a begynning." Camden says that Hereford owes "its greatest increase and growth to religion and the martyrdom of Ethelbert."

The walk from Hereford to Sutton Walls is interesting to the geologist who has learnt that the surrounding hills of Old Red Sandstone consist of the Cornstone series to their summit, the Brownstones being denuded. The railway excavations on the line towards Shrewsbury, are in Lower Old Red Sandstones, and are interstratified with Cornstones containing Pteraspis. Cephalaspis Lyelli has been found in these strata, and I have seen the plates of Pteraspis in stones lying around Sutton Walls and Marden.

Dynedor Hill, S.W. of Hereford, consists of the Cornstone strata, but the sections are not satisfactory. The camp on the summit of the hill is said to have been occupied by the Romans under Ostorius Scapula, although the principal reason for investing it with such dignity appears to have arisen from the fact that it was once called "Oyster Hill." *

There is good field work for the geologist to the westward of Hereford, while some old history is attached to every village tower, or hill summit. The White Cross, that old relic of generations long since dead, on the steps of which many a pilgrim has rested in the days of yore, stands at the cross-roads leading to Weobley and Hay, only a mile from the old city itself. Tradition ascribes its erection to Bishop Cantilupe (1282) who, in commemoration of a miraculous ringing of bells at the cathedral, which he heard when journeying thither from his palace at Sugwas, built the cross on the spot where he first heard the bells. Dr. Duncombe, however, affirms that it was erected in 1348 by Dr. Charlton, afterwards Bishop of Hereford, on the site where the weekly markets were held, during the visitation of a plague, known as "the black dethe."

* Gibson's Camden, p. 579.

A pleasant walk from the White Cross will soon place the rambler on Credenhill, a fine bold eminence of Cornstone. Of late years much stone has been raised there for railway and other purposes, but the only fossils are remnants of fish plates, and a few fragments of plants. On the summit of this hill are the remnants of a large Camp, supposed to have been the summer station of a Roman army, when the city of Magna (Kenchester) flourished within two miles of its base. "Kenchester," says Leland, "is far more ancient than Hereford, and was celebrated in the Roman's time as apperith by many things, and especially by antique money of the Cæsars. By likelihood men of old time went from Kenchester to Hay, and so to Breknock and Carrmardin. The place where the towne was is all overgrown with brambles, hazels, and like shrubs." Here, in 1669, a tesselated pavement was discovered, and we learn from Aubrey's Manuscripts that in 1670 buildings of Roman brick were found, on which grew oak trees. A hypocaust was also discovered about the same time. The then Dean of Hereford, the Very Rev. John Mereweather, opened up many vestiges of this ancient Roman city.

Weobly is a quaint old town with curious timbered houses, and possessing one of the most remarkable church towers in the county of Herefordshire. From the days of Edward I. up to the time of the Reform Bill, it returned two members to Parliament. It is a good locality for examining the phenomena which is presented by the hard Cornstone and sandstone hills resisting the effects of denudation by former seas. The lowest beds at Weobly are Cornstones, with Cephalaspis, succeeded by thick sandstones, which are again followed by Cornstones and sandstones.

Robin Hood's Butts, Lady Lift, near Foxley, and Wormsley Hill are all worth a visit. The strata, of which these adjacent hills consist, were certainly once continuous; and, without doubt, they were also once continuous with strata which now underlie the Upper beds of the Blorenge, the Scyrrid, and the Black Mountains, distant as these hills now appear, when seen from the summit of Lady Lift or Credenhill. The Upper beds, with

vegetable remains, above Mr. Peploe's park, are probably the equivalents of those on the top of Rowlestone near Pontrilas, and also of those above Cusop, near Hay, which contain Stylonurus and remains of plants.

Large quarries have been worked in the Lower Old Red at Lugwardine, south of Hereford, where fragments of fish may be found, but the sandstones rarely yield any but broken and triturated remains. The section is worth examining, as Drift occurs on the hill at Hagley; and a mile and a half further S.W. the Upper Silurians and Passage beds are elevated in a dome. Near Lugwardine is the Trap dyke which alters the Old Red at the little hamlet of Bartestree. Sir R. Murchison describes this trap as "a highly crystalline greenstone, made up of hornblende and felspar." The rocks into which the ancient lava is infiltrated by a fissure, belong to the lowest division of the system.

In the neighbourhood of Malvern the best Old Red section occurs at the northern extremity of the parish of Cradley. Here, as at Ledbury, there is a fault intervening along the line of the Cradley brook, between the Bone bed and the Passage beds of Hales-end, and the Old Red of the hill on the north. On ascending the hill from Stifford's Bridge to the great quarry on the summit, we see Cornstones and Marls cropping out on the flanks, and the western flank when quarried for road stone, yielded relics of Pteraspis rostratus, Scaphaspis Lloydii, and C. Lyellii. These sandstone strata represent, in my opinion, the summit of the Lower Cornstones of the Abergavenny districts. The Cradley sandstones have been largely employed at Malvern for building purposes, and that fine edifice, the College, is principally erected of these Old Red strata. The only fossils I ever saw in these Upper beds at Cradley, were a few remains of plants, but they were too triturated to make anything of the structure. And this is the case generally throughout the Old Red district. The fossil fish, plants, and crustacea are found only in limited zones, the sandstones as a rule, being destitute of anything but an occasional cast of a spine. Mr. Gill of Cradley, paid a good deal

of attention to the fossils in his district, and most of the specimens in the museums at Worcester and at Malvern, both at Dr. Grindrod's and the College, were of his collecting. These specimens were principally found in some small quarries opened for road metal near an old timbered house about a mile from the great quarry on the hill. They were unusually fossiliferous, and from them, Mr. Ray Lankester obtained the tail of a Pteraspis with the scales attached. In the Acton Beauchamp district, a little to the west, there are quarries, which afford Zenaspis Salweyii. Old Red Cornstones are exposed at Heitington, near Bewdley, and contain the plates of the same species of fish.

Near Ledbury the Lower Old Red is best seen between the Bush Pitch, where there is a railway cutting, and the summit of the Wall Hills. At the Bush Pitch, at the base of the hill, some fish spines and scales of Pteraspis were found by Henry Brooks of Ledbury. On the south side of the hill, is a large unworked quarry in thick bedded Cornstone, capped by reddish Sandstone, which yields here and there fragments of a fish which I believe to be Zenaspis Salweyii. The adjacent hills around Canon Frome and Bosbury consist of Sandstones and Cornstones, containing plates of Pteraspis and Cephalaspis.

I would now transport the reader to the picturesque districts of Pontrilas, Kentchurch, and Rowlestone, on the borders of Herefordshire and Monmouthshire, for the study of some of the Upper beds of the Lower Old Red. Close to the railway station at Pontrilas is a quarry of sandstone which affords a fair section; and some years ago the plate of a Cephalaspis was still adhering to a stone in the tunnel. From these railway beds I and my friend, the Rev. William Thackwell, obtained Parka decipiens, and remains of plants, with here and there portions of the plates of Scaphaspis or Pteraspis. Above these strata are the Cornstones of the High Common of Ewyas Harold; and it is this hard Cornstone which arrested the denudation which has been so rife in this district, and which occupies the plateaux of many hills in this part of Herefordshire and Monmouthshire These Ewyas Cornstones are not on the same zone as those

on the *upper flanks* of the Black Mountains, though both yield fish remains, which however are far more sparse in the upper zone. I saw portions of the plates of Pteraspis and a fish spine last year, in the Upper Cornstones when descending from the Black Mountain to Hay. Besides occurring in the railway beds at Pontrilas, Parka decipiens, (or the egg packets of Pterygotus) has been found on the common of Ewyas Harold; in the beds which cap the hill at Rowlestone; and also at Cusop, near Hay. This fossil marks no particular zone in the Old Red, as it is found in the very basement strata that abut on the Passage rocks. The castle of Ewyas Harold stood on Cornstones which form a concretionary limestone, such as, in former days, was burnt for lime in many parts of Herefordshire. In these beds fish remains occur, usually of a fragmentary character. A fine specimen of C. Lyellii was found some years ago on the Common; and in the quarry at the summit of the Common, Dr. M'Cullough obtained a new Pterygotus; Pterygotus taurinus (Salter).

Proceeding from Ewyas Harold up the opposite hill to Rowlestone, thick marly and sandy beds cap the summit of the hill, and were formerly quarried near the church. These Rowlestone strata are, in my opinion, the equivalents of the building stones of Cradley which overlie the fish-bearing strata on the Bromyard road, and also the equivalents of a similar series of deposits which, at Cusop, near the town of Hay, in Breconshire, overlie the Lower Cornstones, and underlie an Upper Cornstone series which are associated with the Brownstones of the Black Mountains. The Rowlestone beds have yielded the fossil crustacean, the "Stylonurus Symondsii" of "Siluria," which has not hitherto been found elsewhere; a Cephalaspis; and the remains of a giant Isopod, Præarcturus Gigas (Woodward), discovered by Dr. M'Cullough of Abergavenny, and figured in the "Transtacions of the Woolhope Club," by Dr. Bull. The geologist who has traced the Lower Old Red from Kilpeck, Whitfield, and Pontrilas upwards through the hills of Rowlestone, Kentchurch, Grosmont, and the Graig, will comprehend the geology of the district and the

succession of a series of strata, which are nowhere better developed than in this picturesque border-land; but walking up to a quarry, and finding a plate or two of a fish, should not satisfy the physical geologist with respect to the horizon of the strata he is examining.

In exploring this district many interesting historic remains claim the attention of the antiquary. Near Pontrilas is Kilpeck church, with its Norman apse, standing close by the ancient castle of the family of Kilpeck, who lived there in the days of Edward I.; but the castle was in ruins when Leland wrote. To the west, on the banks of the river from which it takes its name, stands Abbey Dore, founded in the reign of Henry I. by Robert, Lord of Ewyas, for Cistercian monks. The church was completed during the reign of Henry III., after a hortatory letter by Peter de Aqua Blanca, Bishop of Hereford. The tomb of this Bishop is one of the most remarkable in the Cathedral of Hereford. Several of the abbots were eminent men. One, named Cadugan, was Bishop of Bangor in the time of King John; and in 1236 he gave up his bishopric to become a monk of Dore Abbey. Another was Richard Stradel, celebrated for his religious treatises; while a third was one of the special ministers appointed by Edward III. to treat with the King of France. The remains of the church, with its remarkable chancel, stone altar, and massive tower, tell of its former magnificence.

A mile to the east of Pontrilas is Kentchurch Court, called by Leland "Penchirche, the seat of the eldest House of the Escuedamours." The renowned chieftain Owen Glyndwr is said to have died here in obscurity, and is believed to have been buried at Monnington-on-the-Wye. At Kentchurch lived also John of Kent, a mathematician and poet. The tradition is that he sold his soul to the devil, and constructed the bridge over the Munnow in a single night. A mile beyond Kentchurch are the ancient church and ruined castle of Grosmont. The church is of Transition Norman architecture, with a remarkable octagonal tower. The castle was formerly the residence of the dukes of Lancaster, and was

the scene of many a conflict. Lambardi quaintly says of one of the sieges which it stood in the reign of Henry III., "The King coming with a great army to raise the siege, whereof as sone as the Welshmen had understanding they saved their lives by their legges." Here, also, Henry of Monmouth defeated the Welsh in a great battle in 1405, and took prisoner Griffith, the son of Owen Glyndwr.

Three miles lower down the river are the ancient ruins of Skenfrith Castle. Its area forms a trapezium, and it is believed to be the most ancient fortress in Monmouthshire. Leland speaks of it as being nearly perfect in his time; but a survey, made during the reign of James I., describes it as "ruinous and decayed—time out the memory of man." At the period of the Norman invasion, Skenfrith was the residence of a Welsh prince—Bach, son of Gwaithvoed, Prince of Cardigan; but shortly afterwards it became a Norman stronghold, like Grosmont and Longtown. At Rowlestone the little church should not be neglected, for there is a wonderful chancel arch, and beneath the carved canopy is a strange old effigy of a lady holding her heart in her hand.

The derivation of the name of Ewyas Harold is a mooted point among archæologists and antiquaries. The Rev. W. Fowle believes that it is derived from "Ea," Saxon for water; but only a very small stream runs near. Mr. Flavell Edmunds of Hereford, a learned student on the origin and derivation of names, considers that Ewyas comes from the British "Yw, ys," the place of yews; and these trees flourish here still in abundance. The lord of the castle bore, without doubt, the name of Harold; but who he was is a subject of dispute. Mr. Freeman, author of the "History of the Norman Conquest," believes that he was the natural son of one "Drogo Fitz Pontz." Leland says, "The fame is that the castle of Map Hærald was builded of Harold afore he was Kynge, and when he overcâme the Walsche men." He describes the extent of the domain as "a myle in breadth where it is narrowest, and most in length two myles. It hath good corn and grasse and woode."* After

* Itin., vol. vii., p. 83.

the death of Harold, the Conqueror appears to have given it to Alured de Marleborough, who possessed it at the time of the Doomsday survey. Leland, when speaking of the inhabitants of Talgarth and Ewyas, says, "The natives of these parts, actuated by continual enmities and implacable hatred, are perpetually engaged in bloody contests."

Having made acquaintance with the upper rocks of the Lower Old Red in the Pontrilas district, the geologist should proceed to Abergavenny. Abergavenny was the site of the Roman station Gobannium of Antoninus, and lies embosomed among the hills of the Scyrrid Fawr on the east, the Sugar Loaf on the north-west, and the Blorenge on the south.

The Castle is a mere ruin and appears to have been very dilapidated even in the time of Queen Elizabeth, for Churchyard wrote of the towers as "bare and naked left," and prayed,

> "Would God, therefore, the owner of the same,
> Did stay them up for to increase his fame."

It occupies a good position towering above the Usk, but had a grievous reputation through the abominable atrocities committed by the Normans against the Welsh; atrocities worthy of a Front de Bœuf. It was here that William de Braose invited several Welsh chieftains to his hospitality and then butchered them in cold blood; and it is of Abergavenny Castle that Giraldus remarks that "it was dishonoured by treason oftner than any fortress in Wales." Giraldus relates that when he and the Archbishop were at Abergavenny, and many persons were converted to the Cross, a certain nobleman of those parts named Artheum, came to the Archbishop, who was proceeding towards the Castle of Usk, and humbly begged his pardon for having neglected to meet him sooner. Being questioned whether he would take the cross, he replied "That could not be done without the advice of his friends;" the Archbishop then asked him "are you not going to consult your wife?" He modestly answered with a down-cast look, "When the work of a man is to be undertaken the counsel

of a woman ought not to be asked," and instantly received the cross from the archbishop!

With respect to the geology around Abergavenny the explorer will have no difficulty in recognizing a portion of the Cornstone strata of the Old Red in the railway cuttings between Abergavenny and Llangvihangel. These are the lowest beds exposed in the district, and the Upper Cornstone group rises into the hills named the Deri and the Rolben below the Sugar Loaf, and again into the wooded escarpments that lie below the Blorenge. Above the Upper Cornstones and Sandstones of the Deri and the Rolben, the Brownstones set in, and those unfossiliferous deposits constitute the higher strata of the Sugar Loaf, and the Scyrrid Fawr; while in the Blorenge the Brownstones are themselves overlaid by the uppermost rocks of the Old Red, viz., the Old Red Conglomerate and the yellow and grey sandstones, these again being capped by the Carboniferous Limestone and millstone grit. The Lower Flagstones and Cornstones around the town are fossiliferous, and there are some fine specimens of fish scales, heads, tails and spines in the collections of Dr. Elmes Steele and Dr. M'Cullough. Some of these were obtained from beds upon which the Asylum stands, with some fine plates of Cephalaspis, and one or two remarkable Ichthyodorulites or fish spines. Again some good scales have been found in higher Flagstones and Cornstones at the base of the Scyrrid; and among them a magnificent shield of the head of Zenaspis Salweyii was found by Mr. Steele. I am not aware that any fish remains have been found in the upper beds on the Deri and Rolben.

Every geologist should ascend the Scyrrid Fawr, as its summit commands a splendid view of the surrounding country. There is a downthrow on the Scyrrid, from the Sugar Loaf series which is not altogether satisfactory to those who have little time to spare for fault investigations. Every one, however, should see the Scyrrid and the escarpment of Brownstones laid open by the great slips which have descended from the northern slope. At the summit of the Cornstone group there is probably a break in the stratigraphical succession,

for the Brownstones overlap the Rowlestone beds both on the Scyrrid, and the Sugar Loaf. It is on this line of break that denudation appears to have been arrested throughout a large area of the Cornstone hills of Herefordshire and Monmouthshire. There are numerous hills where the Brownstones are denuded and only just denuded. We hope that local geologists will one day clear up this important question. This, however, can hardly be done without much trouble and research, nor by any but those who can give time and attention to the study of the phenomena of the district.

Llantillio Crosseney should be visited from Abergavenny for the sake of the White Castle (Castell Gwyn) which was standing at the time of the Norman invasion, and was the habitation of Sir Gywn ap Gwaithfoed, Prince of Cardigan.

Near Col. Clifford's park are the relics of an old house said to have been occasionally the residence of Sir David Gam, the faithful squire of Henry V., who, when sent to reconnoitre the French army before the battle of Agincourt, said that "there were enough to fight, enough to be killed, and enough to run away." It was of such men as Gam, who was knighted by his master, as he was dying at his feet, that Fluellen is said by Shakespeare to have reminded the king that "the Welshmen did goot service in a garden where leeks did grow, wearing leeks in their Monmouth caps."

The neighbourhood of Abergavenny was rich in heroes in olden days, for again about four miles to the north east and near Pandy station, is Old Castle, which every lover of religious freedom should visit in homage to the memory of Sir John Oldcastle, Lord Cobham, who suffered an ignominious death as a traitor and a heretic. He was the early friend of Henry V., the defender of religious liberty and of the persecuted Lollards, the follower of Wickliffe, and as Horace Walpole says, "the first author as well as the first martyr among our nobility!" The last time I visited Old Castle I saw, at the farm-house close by, an ancient portrait which "old people said was a true likeness" of one who helped to plant the standard of the Reformation in the English church. Alas! he, like too many

who lived before his day, and others who have lived since, found that any attempt to develop religious truth is followed of necessity by persecution on the part of the ecclesiastical powers that be.

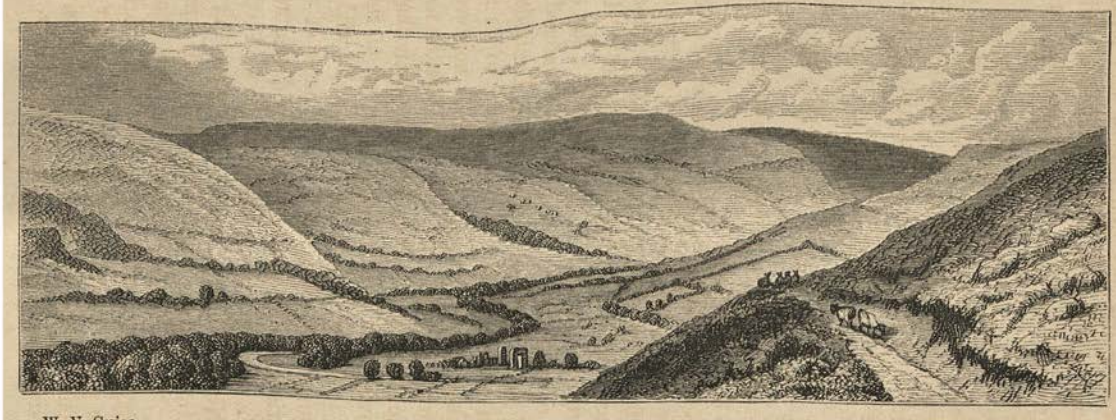
There are few more beautiful ruins than those of Llanthony Abbey, distant about six miles from the Llanvihangel station on the Hereford and Abergavenny Railway, and situated in a wild and secluded valley among the hills of the Black Mountains; hills where

> "Moorcock springs
> On whirring wings
> Amid the blooming heather,"

and where ages ago the hermit chose this secluded spot for retirement from the world.

Giraldus Cambrensis gives a long account of the foundation and history of this Abbey and speaks of its "situation as truly calculated for religion and more adapted to canonical discipline than all the monasteries of the British isle." "It was founded by two hermits in honour of the retired life, far removed from the bustle of mankind in a solitary vale watered by the river Hodeni." From Hodeni it was called Lanhodeni, for Lan signifies an ecclesiastical place. "Owing to its mountainous situation the rains are frequent, the winds boisterous, and the clouds in winter almost continual." "Here the monks sitting in their cloisters, enjoying the fresh air, when they happen to look up towards the horizon behold the top of the mountains as it were touching the heavens, and herds of wild deer feeding on their summits." According to the notes of antiquaries a small rustic chapel dedicated to St. David was first built on or near to the site of this abbey, whither in 1103 William de Laci, a Norman knight, retired, and was afterwards joined by Ernicius, chaplain to the Queen Maud, consort of King Henry I. These hermits erected the first "mean church." At the request of Ernicius, Hugh de Laci, Earl of Hereford, founded a priory for Black Canons of the order of St. Augustine. Henry I. and his queen were benefactors, and Giraldus Cambrensis, who evidently visited Llanthony, describes the

LLANTHONY ABBEY, AND HILLS OF OLD RED SANDSTONE.



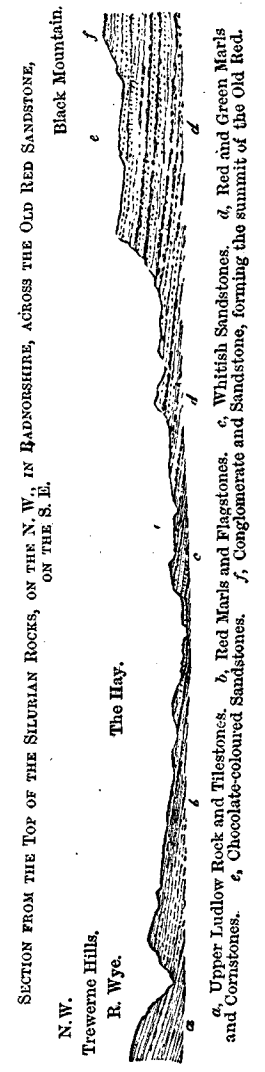
W. V. Guise.

conventual church as a good building having "an arched roof of stone and covered with lead." Evil days arose and the monks of Llanthony were ill-treated and pillaged by the Welsh, so their former prior, Robert de Betune, Bishop of Hereford, enabled them to erect a new monastery near Gloucester in the year 1136, and the church among the mountains was gradually despoiled of its valuables to enrich the monasteries at Gloucester. Giraldus also says concerning the stones of the Black Mountains near Llanthony, "Parian stones are frequently found there and are called free stones ("qui et liberi vulgo dicuntur") from the facility with which they admit of being cut and polished; and with them the church is beautifully built. It is also wonderful that, when after a diligent search all the stones have been removed from the mountains and no more could be found, upon another search a few days afterwards they appear in greater quantities to those who seek them."

In this district, there is good work for the physical geologist in tracing up the Old Red strata along the hill sides, in the gullies and brooks. An interesting route passes by Capel-le-fin, a little Welsh chapel among the hills, and in following the stream to the base of the Black Mountains the explorer arrives at a small waterfall. On the left of the waterfall, under the hill, is a considerable mass of travertine, a station for the somewhat rare fern Asplenium viride, and covered, in summer time, with a small Saxifrage. This travertine owes its origin to the percolation of water through a thick band of cornstone which may be seen *in situ* in the rocks above. These are, as far as I know, the highest Cornstones of this district, and they are succeeded by the great mass of Brownstones which, in the high hill to the west, called the Gadir, rise to a height of 2000 feet, and from the summit of which the geologist will not fail to remark that the Carboniferous deposits are only just denuded. The geologist should now cross the hills to the Hay in Breconshire, and examine the Upper Silurian section on the banks of the Wye near Trewerne, and follow up the rocks, in ascending order, by Cusop, to the Brownstones on the summit

of the Black Mountains. Sir R. Murchison records an attempt made to find coal some years ago; the undertaking was suggested by the quantity of carbonaceous matter contained in some of the Old Red Flagstones. Vestiges of this attempt at mining may still be seen on the eastern side of a ravine above the village of Cusop. I believe that these strata are the equivalents of the Stylonurus Flagstones of Rowlestone near Pontrilas, and overlie the Lower Cornstones. From the Cornstones, below the (Rowlestone) flags and building stones of Cusop, I obtained, last summer (1871) through the kindness of Mr. Thomas, C.E., of Hay, a very fine fish spine, which has been named "Onchus major" by Mr. Etheridge, and is the largest yet found in the Lower Old Red Sandstone. It was exhibited at the meeting of the British Association at Edinburgh, and is now in the museum of the Earl of Enniskillen.

The early history of the town of Hay is involved in obscurity. Leland and Camden both state that Roman coins have been dug up here, and the latter says that it is "a place which seems to have been well known to the Romans." In the time of William Rufus the manor of Hay fell into the hands of Bernard Newmarch, who probably erected the Castle; at all events, it was built before the days of Giraldus Cambrensis, for he records "preaching a sermon at Hay," and alludes to "the


Section from the Top of the Silurian Rocks, on the N.W., in Radnorshire, across the Old Red Sandstone, on the S.E.
Black Mountain.
N.W.
Treweme Hills.
R. Wye.
The Hay.
a, Upper Ludlow Rock and Tilestones. b, Red Marls and Flagstones. c, Whitish Sandstones. d, Red and Green Marls and Cornstones. e, Chocolate-coloured Sandstones. f, Conglomerate and Sandstone, forming the summit of the Old Red.

Castle." It was taken in 1265 by Prince Edward, together with the Castle of Brecon, and its final destruction is attributed to Owen Glyndwr in 1403. Leland describes its ruins and says that it "hath been some time right stately." On its site now stand the Parsonage, covered with ivy, a portion of the walls, and a gothic gateway.

Within a short walk of the Hay is Clifford Castle, the birthplace of Rosamond Clifford, the mistress of Henry II. The ruins of this Norman castle stand upon a hill of drift, the deposits of an ancient Wye, which, long ages before the days of the Plantagenet, swept over the site where the ruins are now crumbling to decay. During the excavations made for the railway along the base of the castle hill, the workmen came upon a bed of bones partly stratified in the gravel. I examined the site and the bones, which were all appertaining to existing animals, the ox, boar, and deer. The animals must have been swept down in a flood and entombed at a remote period, as one hundred feet of stratified silt and gravel lie above them. I have to thank Mr. Curley, C.E., of Hereford, for calling my attention to these drifted bones. Unfortunately, the hill-side sections are much masked by drifts of another character, viz., the débris brought down by the land ice and snow, which in the latter days of the Glacial Period swept down the sides of the mountains and bore along large masses of local débris from the Old Red Hills above.

The village of Brynllys lies on the road between Brecknock and Hay. Giraldus Cambrensis speaks of "the castle of Brendlais" and notes that while Mahel, a son of Earl Milo, "remarkable for inhumanity," was "being hospitably entertained by Walter Clifford, the house was by accident burned, and he (Mahel) received a mortal blow by a stone falling from the principal tower on his head." The round tower still remains, and the church preserves its Norman windows. Llanthew, a village two miles from Brecknock, was occasionally the residence of Giraldus. He says concerning it, "In these temperate regions I have obtained a place of dignity but no great omen of future pomp and dignity, and

possessing a small residence near the Castle of Brecheinoc, well adapted to literary pursuits and to the contemplation of eternity."

An agreeable day's ramble from Hay may be had by taking the rail to Letton station and walking by Brobury Scar, a good Lower Old Red section on the Wye, through the village of Bredwardine to the very fine cromlech on Merbridge Hill. It is known by the name of "Arthur's stone," and rests in the middle of an old road with a small mound near at hand. It is in a good state of preservation. The large incumbent stone was no doubt hewn from the rock close by. The rock was exposed *in situ* some summers ago, which enabled me to arrive at this conclusion. The other stones, some of which have fallen from their originally upright position, belong for the most part to the hard limestone of the Cornstones and are not *in situ* on the horizon of the cromlech, but lie scattered about as boulders upon the land. All the stones belong to the Old Red Sandstone of the country.*

In Caermarthenshire, a section on the River Sowdde near Llangadock has already been alluded to, where the Lower Old Red may be traced from the Upper Ludlow and Passage Rocks at Pont-ar-lleche, through a series of marls and thin bedded limestones in the vale of Gwinfe, up to the Brownstones and Conglomerate of the Caermarthen Vans. This is an important section, the beds being highly inclined. It appears, the upper Cornstones of this section are unconformable with the Brownstones of the mountains above, and there seems also to be an overlap which requires attention. Again, towards Caermarthen, the question arises as to whether the Conglomeratic series of the Upper Old Red does not overlap the Lower Old Red. In this district I suspect there is a break in the succession of the strata between the Upper Cornstone series, and the Brownstones, and again between the Brownstones and the Conglomerate farther south.

The old fortress of Llanstephan Castle stands upon a bed of

* The return walk may be made over the old British Camp on Merbridge Hill by the Clock Mills to Eardisley station.

crystalline Cornstone which probably represents the upper beds of the Lower Old Red. In South Pembrokeshire are two localities where the Old Red may be seen in contact with Upper Silurian rocks, viz., at Freshwater East and Freshwater West. I visited the eastern section, but it is an unsatisfactory place for determining the relation of the beds, as they are much obscured by blown sands. From Llamphey, which is situated on the Carboniferous Limestone, I crossed over the Old Red Sandstone by Parelew to Freshwater Bay, and found a small quarry of nearly vertical Silurian rocks, on the hill above the bay and on the right hand of the road leading to Stackpole. The Old Red basement rocks consist of a conglomerate of Silurian pebbles, consequently the Lower beds are probably wanting. The section at Marloes Bay is interesting. The Lower Old Red is seen at Hook Point on the east, at Gateholm Island and at the opposite promontory on the west of the bay, in contact with Upper Ludlow strata. The Upper Silurians are here faulted through the Old Red and interlaced with volcanic dykes.

Igneous rocks may be seen in contact with Old Red Sandstone in the grounds of Mr. Warren Davis of Trewarren, St. Ishmael's. They occur to the west of the Church. At Benton Castle, on the right bank of the river Haverford, volcanic rocks are erupted through Old Red strata. Towards the west the range of the Johnston traps traversed the Carboniferous deposits as well as the Old Red; and Sir H. de la Beche records that he saw a large fragment of Carboniferous Limestone twisted into a large mass of trap.

The Isle of Skomer off the south western coast consists entirely of trap rocks. During my last visit to Pembrokeshire I saw a number of the eggs of our rarer British birds, which had been collected by a lady and gentleman who had resided for many years on this lonely island; they were carefully preserved in a cabinet at Solva near St. Davids, and they included the eggs of the Woodcock, Snipe, Golden Plover, Whimbrel, also of the Cornish Chough, Peregrine Falcon and Stormy Petrel.

W. V. Guise.

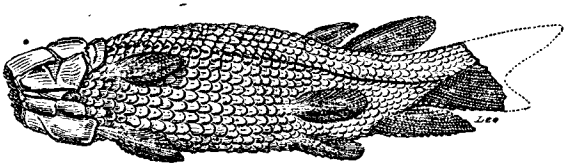
MARLOES BAY, 1865—GATEHOLM AND PART OF SKOMER ISLAND.

[*Page* 242.

BROWNSTONES AND UPPER OLD RED SANDSTONES.

In Scotland the researches of Prof. Harkness and Mr. Powrie have established the fact that the Lower Old Red is characterized by the presence of Cephalaspis, Pteraspis, and other peculiar fishes, as in the Silurian districts of Herefordshire and Monmouthshire. The Middle Old Red of Scotland furnishes the fossil remains of numerous well preserved fishes, the best known of which are the Pterichthys, Coccosteus, Cheiracanthus, Diplacanthus, Cheirolepis, Dipterus, Osteolepis, and Diplopterus, all described by the graphic pen of the late Hugh Miller in his famous work "The Old Red Sandstone."

GANOID FISH OF THE OLD RED SANDSTONE.



Dipterus macrolepidotus, Ag., of the Black Schists of Caithness. From a specimen in the cabinet of Sir Philip de M. Grey Egerton, Bart.

The Upper Old Red of Scotland is characterized by the presence of a peculiar Pterichthys, and the large scaled fish Holoptychius. A closely allied form of this Pterichthys is found in the Upper Old Red strata of Farlow, in Herefordshire near the northern base of the Titterstone Clee, while the remains of Holoptychius have also been detected in strata overlying the Old Red Conglomerate on the Daren near Crickhowell. Unfortunately no fossils have hitherto been discovered in the Brownstones, *i. e.*, those Old Red beds which in Siluria immediately underlie the Old Red Conglomerate, and overlie the Cornstone group. Some geologists have supposed that the central strata of Scotland, so rich in fishes, are wanting in Siluria. It is my belief that the Brownstones represent the Osteolepis bearing rocks of Scotland, and that

physically, they are largely developed in the mountains of Breconshire and Monmouthshire. A fair section of the lowest Brownstone beds may be examined at the Scyrrid near Abergavenny, where a landslip has laid bare the upper portion of the hill. They are capped by a marly conglomerate and dip away from the opposite hills of the Sugar Loaf and Black Mountains towards the Carboniferous rocks of Dean Forest. When examining this district some years ago I thought, from the dip and strike of the strata, that the Brownstones must have extended from the Scyrrid in the direction of the Sugar Loaf as a huge anticlinal in the direction of Pen-Cerrig-Calch. There are no sections on the Blorenge, or the Sugar Loaf, or on the Black Mountains, excepting where the rocks are partially bared by mountain rills.

In the district of the Forest of Dean these rocks have very much thinned out, but they may be seen by commencing at the Lower Old Red of Pyrton Passage and following the successive beds by Blakeney and Bryant's Green to Soudley Green. The Old Red in this district is much denuded, as well as thrown down and dislocated by faults. Anyone who has studied the physical geology of the Brownstones and flagstones in the mountain ranges of Brecon and Caermarthen will be led to the determination that these strata of the Old Red system must formerly have extended over a large extent of surface now occupied by the Lower Old Red and Silurian deposits, from above which they have been denuded. In certain directions they are evidently thinned out as compared with the thick masses occurring in Breconshire and Caermarthenshire, but there can be no doubt of their former persistence over a far larger area than they occupy at present.

The ancient British town of Aberhonddu, commonly known as Brecon, lies surrounded by old rocks and old ruins, while we agree with Hoare that it can hardly be surpassed for the picturesque beauty of its situation. "The different mills and bridges on the river Usk, and Honddu, the ivy mantled walls and tower of the Old Castle, the massive embattled turret and

gateway of the priory, with its luxuriant groves added to the magnificent range of mountain scenery on the southern side of the town, form in many points of view, the most beautiful, rich and varied outline imaginable."

The Castle was once the residence of Henry, Duke of Buckingham, who was executed at Salisbury by the orders of Richard III., although he was the "first that helped him to the crown" and "the last that felt his tyranny."—Leland says of the castle, "The castel stondith in the suburbe and is devided from the toune by the Hondency river over the wich is a hy bridge of 2 arches to go into the castel, the wich is very large, stronge, welle mainteynid; and the keep of the castel is very large and faire." During the reign of Charles I., the inhabitants nearly demolished the castle to avoid a siege. The unfortunate monarch was notwithstanding hospitably entertained at the Priory by Sir Hubert Price, and there he wrote the well known letter to the Prince of Wales advising him to fly to France.

The Church of St. Almedha is mentioned by Giraldus Cambrensis*; the saint was one of the twenty-four daughters of Brachanus "in ancient times ruler of the province of Brecheinoc and from whom it derived its name." He relates that at the anniversary of the holy Saint Almedha, "you may see men and girls, now in the church, now in the churchyard, now in the dance, which is led round the churchyard with a song, on a sudden falling to the ground as in a trance, then jumping up as in a frenzy and representing with their hands and feet before the people whatever work they have unlawfully done on feast days."

Three miles above Brecon, near the confluence of the rivers Yscir and Usk is the Gaer-Bannau, the Bannium of the Romans, where according to Mr. Jones, the historian of Brecknockshire, Ostorius Scapula built a fortress, and where gold coins of Nero and Trajan have been found associated with bricks, one of which still bears the inscription LEG. II

* Hoare's Giraldus Cambrensis, vol. i. p. 35.

A. U. G. Until the days of William Rufus, Gaer-Bannium was the site of the principal town of Brecknockshire; it was then destroyed by the Norman knight Bernard Newmarch, who made the Welshmen carry away the stones of which it was built for the purpose of erecting his stronghold at Brecon. The Castle Hotel now stands on the site of this fortress, and hard by is the church of St. John, formerly the chapel of a priory founded by Newmarch for the good of his soul after a lifetime of savage violence, murder, and plunder. The geologist who visits the Gaer will observe a number of boulders of Old Red from the neighbouring hills lying all along the remains of the Roman road which leads by the "Maiden's Stone" to the Gaer. There is little doubt that boulders of large size were once scattered over the surrounding lowlands, but as cultivation increased they were broken up for roads and built into walls. The "Maiden Stone" (Maen-y-morwynion) is a large slab of Old Red with sculptured figures; it is probably a boulder set on end. Newton near Brecon was the birthplace of Sir David Gam.

The highest mountain peaks in South Wales are the Bannau Brecheinog or the Brecknockshire Beacons. They lie about five miles to the south-west of the town, and rising to a height of 2862 feet they command a noble view of very distant points in the surrounding country. The rocks on the summit consist of the Brownstone series of the Old Red which dip to the south under the Old Red Conglomerate and the Carboniferous Limestone of the South Wales coalfield. The summit of the Brecon Van is somewhat precipitous on the northern slope, where the rocks rise in a bold escarpment from a coomb which, we have no doubt, was once filled with the ice of a small glacier which stretched for a considerable distance down the vale. Indeed everywhere around these hills there are vast masses of angular local drift which have been swept down by land-ice and snow, those effective agents, which throughout a long period transported large boulders and lodged them at high levels and low levels along the flanks of the hills and against the sides of the valleys, so as in some instances to form

moraines. There is a marly conglomerate on the Brecknockshire Vans similar to that on the Scyrrid. These are the basement beds of the quartzose conglomerates which underlie the yellow sandstone and the lower limestone shale of the Carboniferous rocks. It is lower in the series than the *quartzose conglomerate* which has been denuded from above the Vans of Brecon. The strata now on their summit are the equivalents of those which cap the Caermarthenshire Beacons on the west, and the Gadir Vawr on the north-east across the valley of the Usk above Talgarth, and they underlie the isolated outlier of Carboniferous rocks at Pen-Cerrig-Calch. The lake of Llyn Cwm Llwch lies below the Vans, and the depression which the waters now fill is surrounded by moraine matter brought from the summit of the Vans.

Talgarth is a good locality from whence to visit the Brownstones of the Gadir Vawr, and those of Skethrog and Derwaddon. It is near also to a fine lake Llynsavaddon, or the lake of Llangorse, celebrated for its fine pike, perch, and waterfowl. This lake is mentioned by Camden as the probable site of the Loventinum of Ptolemy, which "was swallowed by an earthquake." Llynsavaddon affords some good marsh plants to the botanist. The rare Spearwort (Ranunculus lingua) grows here, together with the white Water Lily (Nymphæa alba) and the flowering Rush (Butomus umbellatus). It is, after Bala lake, the largest lake in Wales; and we find that in 1235 the monks of Brecon obtained leave from the Priory of Llanthony to fish in it three days a week, and daily in Lent provided they used only one boat. On the little island at the Llangorse end of the lake there have lately been discovered some remains of prehistoric human habitations, associated with bones of deer, horse, and ox.

The Bwlch, a pass on the road from Brecon to Crickhowell, should be visited, for the Old Red is quarried on the ridge of the hill; and here I once found the cast of a fish spine, and portions of fish plates. Near the road, too, are the ruins of Blaen-lyffin Castle, now only the haunts of rabbits. Under

the Alt is Buckland, the seat of the Gwynne Holfords, the representatives of the ancient family of Gwyns, who trace their descent from Gwrgan, Lord of Glamorgan, and a race who were British Chiefs before Bernard Newmarch had a beginning.

The Boulder drifts along the valley of the Usk are most interesting. There is a fine rolled erratic in the "Chain Pool" near the grotto at Buckland. Lower down the vale is the Maenhir of Llynfedwen, which is a great angular mass of Mountain limestone set upright; while the Maenhir in Sir Joseph Bailey's grounds between Gliffaes and Glanusk is of Old Red Sandstone. Both are erratic masses from the hills above.

It would be interesting to know what has become of a flint implement which was found in this neighbourhood. It is recorded in Jones's Breeknock, that in the parish of Llanelin, to the eastward of Brynllys, was discovered, "within a cairn in a field, a remnant of antiquity, in comparison with which even the Roman remains in this island may be said to be modern; it was a spear head of flint, nearly seven inches long and two broad at the widest place. It is rudely chipped into its present shape, and seems to be more ancient than the use of iron in this country. In the same cairn was also found a coarse earthen vessel."

UPPER OLD RED SANDSTONE.

In Siluria and South Wales, the uppermost strata of the Old Red Sandstone consist of Conglomerates which are overlaid by red marly beds; these are again succeeded by yellow and yellowish grey sandstones which pass upwards (as in Dean Forest) into the Lower Limestone Shale of the Carboniferous series. The Conglomerates of the Upper Old Red differ considerably from the conglomerates of the Millstone Grit, which, at first sight, are often difficult to distingush, as they lie in large boulders on the flanks of the hills. The Old Red Conglomerates consist of quartz pebbles with red jasper in a red pasty matrix, whereas the Millstone Grit pebble beds are

made up of red and white quartz pebbles in a grey or yellowish silicious matrix. The geologist should note this difference in the matrix, which, when once observed, proves a well-marked distinction, as mistakes often occur, especially as regards transported masses of the two conglomerates. For example, the hill of Cefn Bryn in Gower is studded with Millstone Grit boulders resting on Old Red Conglomerate, the Millstone Grit and the Mountain Limestone being denuded from the upper part of the hill on which the boulders are stranded; and yet, the débris of Millstone Grit lie so thick on the Old Red as to be easily mistaken for the rock *in situ*. The upper deposits of the Old Red or substrata of the Carboniferous Limestone are very persistent in Siluria; we find them ranging from the Vans of Caermarthen, girdling the South Wales coal field, underlying Dean Forest and stretching far away on the slopes of the distant Clee hills of Shropshire.

The uppermost strata may be seen in an extraordinary position in Caermarthenshire, about three miles from Llandeilo. They are thrown down from their proper position on the summit of the Caermarthen Vans, with the Carboniferous Limestone of Castel-Cerrig-Cennen, into the vale of the Cennen. I detected their place *in situ* on the rising ground just north-west of Castel-Cerrig-Cennen, when there with my friend Prof. Harkness, several years ago.

The Daren Mountain, two miles north of Crickhowell, is capped by these uppermost sandstones. They were quarried as building stones for the house at Glanusk, the residence of Sir Joseph Bailey. There is some difficulty in detecting the position of the Old Red Conglomerate below the scar of the Daren, as it is masked by débris. Nevertheless, it may be found *in situ* in a small quarry hole to the east of the great quarry on the hill and considerably lower down. From the sandstones on the Daren, Sir R. Murchison records the scales of Holoptychius. There are impressions of stems of plants on the rocks below the Scar. These Daren sandstones occupy the same physical position as the yellow beds of Dean Forest, and as the yellow sandstones of Farlow,

near the Clee Hills, which have afforded the remains both of Holoptychius and Pterichthys.

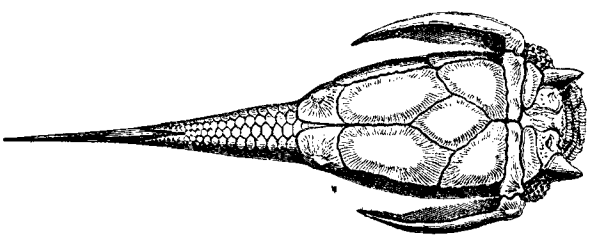
The Conglomerate is exposed on the hills, the other side of the Usk, as on the Blorenge above Abergavenny, but I know of no section of the Upper Yellow and Grey Sandstones. The inscribed stone in Sir Joseph Bailey's park is a mass of Conglomerate, and I was informed once formed a footbridge on the high grounds above Llanwyse.

The visitor to this district should see Crickhowell Castle, its Church and Monuments, and a Cistfaen, hard by the road side to Brecon. Tretower Castle also, and a remarkable Castellated Mansion of the Picards, lords of Ystradzw, are both within a short walk, and are well worth the notice of the antiquarian.

Throughout the district of Farlow, in the Clee Hill country, there has been great dislocation both of the Old Red rocks and of the Carboniferous series; consequently, the sections of strata are unsatisfactory and difficult, and their physical positions are not so well seen as in Dean Forest, and other localities. The Farlow Sandstones afford fossils found, as yet, in no other Silurian regions, and they are famous as having yielded the remains of fishes which characterize the celebrated beds of Dura Den in Scotland. Here Mr. Baxter, of Worcester, found a Pterichthys which Sir P. Egerton pronounced to be closely allied to the Pterichthys hydrophilus of Dura Den. There is also another species of this fish in the collection of Mr. Weaver Jones at Cleobury Mortimer.

The Pterichthys, or winged fish, was first discovered by Hugh Miller, who thus records, in his graphic work, "The Old Red Sandstone," the feeling with which he contemplated his first found specimen. "It opened with a single blow of the hammer, and there, on a ground of light coloured limestone, lay the effigy of a creature fashioned, apparently, out of jet, with a body covered with plates. Two powerful arms articulated at the shoulders, a head as entirely lost in the trunk as that of the ray or the sun-fish, and a long angular tail." The Pterichthys belongs to that group of fish known as Placoganoids or Ganoid fish, protected with plates of enamel.

The remains of Holoptychius (wrinkled scale), a large fish covered with scales of enamel instead of plates, have also been found there by Mr. George Roberts and Mr. Lightbody of Ludlow. Conularia also occur in these beds; and these fossils are the remains of marine Pteropods. Farlow is a wild, out-of-the-way place, with a new church built of the rotten Pterichthys sandstone.



UNDERSIDE OF PTERICHTHYS CORNUTUS, AGASSIZ.

The neighbourhood of Ross, in Herefordshire, may be explored with advantage by the geologist, while the antiquary may see the house where lived "ye man of Ross," and may gather much information respecting John Kyrle, the bishop's dungeons, and the church; how the little church of Bridstowe is built upon the very site where stood a church of wood in the days of King Harold; and how the Greys-de-Wilton lived and died in Wilton Castle, the ruins of which are now seen just across the Wye. There is, too, much to be learnt respecting Goodrich Castle,* a stronghold in the time of Edward the Confessor, when "entrenched in a stockade of wood, Goderic de Winchcomb held the Ford." And there are also accounts of the Ariconium of the Romans, and the Hellan (or Old Church, now Hentland) of Dubritius. At Pengethly, the seat of my cousin, Lt.-Col. Symonds, in the parish of Hentland, Pope is said to have written his celebrated poem of "The Man of Ross."† The "Old Church" was restored by my friend, the Rev. W. Poole.

* The reader is referred to "Castles of Herefordshire," by Rev. C. Robinson.
† See Powle's "Ross Guide Book."

Nearly opposite Goodrich, at Hill Court, the residence of Captain Power, are low level Wye drifts with large boulders stranded in the gravel.

There are two or three instructive sections in the Upper Old Red Sandstone, which may be visited from Ross. One is the Dry Brook section on the high road to Ross and Cinderford. Here the transition beds, from the conglomerate of the Upper Old Red to the Lower Limestone Shale of the Carboniferous deposits, are well displayed. There is another section south of Cinderford between the tunnel at Sudely and a place called Ruspitch.* At both these localities, the yellow sandstones, and other strata, yellow, red, and grey, which overlie the Old Red Conglomerate, may be seen passing upwards into the shales of the Carboniferous Limestone. The yellow series of beds is masked in the section below Symonds Yat, on the Wye, excepting when carefully examined. The Old Red Conglomerate occupies the base of the hill below Symonds Yat, on crossing the Whitchurch ferry, while it is elevated on the Great Doward on the right bank of the river.

The Buckstone, one of the most famous rocking-stones in Great Britain, is a detached mass of Old Red Conglomerate which underlies the margin of the Forest of Dean, and the Carboniferous rocks opposite the town of Monmouth. There are several other large masses which have been detached through the atmospheric degradation of the marls below the conglomerate, and have rolled far down the slope of the wooded hills which rise from the valley of the Wye along the escarpments of the forest. Near the Buckstone is Stauton-on-the-hill, a pretty village with a church containing Norman relics, and a curious stone pulpit, which for many years was built up and hidden in a buttress to save it from being destroyed by the Puritans.

Monmouth itself is said to have been built on the Roman

* The former of these two sections may be best reached from the station at Mitchell Dean Road, and the latter from Newnham.

station Blestium. There is but little of interest in the town, save the Welsh Gate and the memories of Henry V.

The geology between Monmouth and Coleford is interesting as we pass from the lower Old Red beds of Wonastow and Monmouth, containing the remains of Cephalaspis, to the Coal measures with their fossil ferns and Calamites. Still further down the Wye to the north of Tintern, the upper Old Red is well marked by thick masses of "pudding stone" which, as at the Buckstone, rise to the summit of the high ground of Wentwood.

The author of the "Secret Memoirs of Monmouthshire" says that the forest of Wentwood was encompassed by six castles, "Dinham, Penhow, Pencoed, Llanvaches, Lanvaire, and Castrogy castles." Little remains of their ruins now, and Leland speaks of Pencoed as only "a fair manor place."

In the neighbourhood of Bristol there is a section at the banks of the Avon river where the upper Old Red Sandstone is developed and is overlaid by the limestone shales.

There are some good sections in the uppermost Old Red in Pembrokeshire, near Tenby, and at the mouth of Milford Haven. The Tenby sections are on the coast of Caldy Island, and at Skrinkle Bay. At Caldy Island the Old Red Sandstone is seen overlaid by yellow sandstones with conglomerates at the top, and these are again overlaid by shales containing Carboniferous fossils. On the eastern side of the island the Upper Old Red beds form the south end of Drinkim Bay, and on the west side Mr. Salter detected Serpulæ in masses of rock about 50 feet down in the Old Red series. The best view of the Skrinkle Bay section may be obtained by proceeding thither in a boat from Tenby, the path over the cliff being exceedingly precipitous. The bottom beds of the Old Red consist of some white sandstones (which occur also at Caldy Island) but there is a fault in the upper strata near their junction with the Carboniferous deposits. When visiting this country with Sir Wm. Guise, we were examining the coast for drift and cave phenomena, and taking no thought of the Upper Old Red and Carboniferous Passage beds, when we came upon this fine

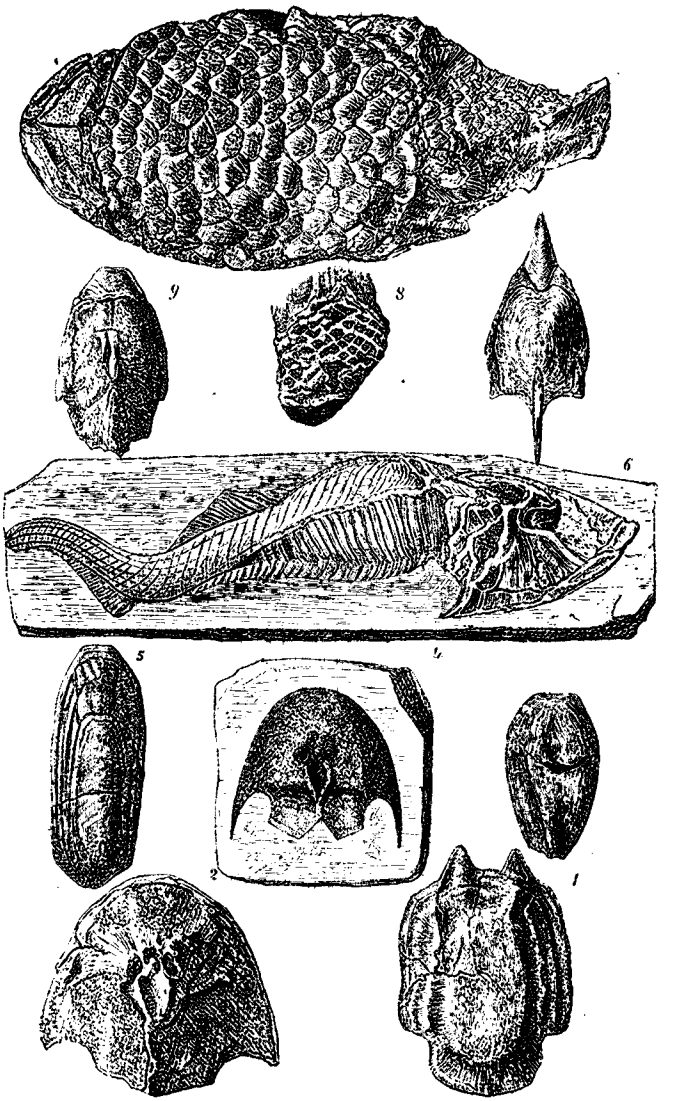
section at Skrinkle, and were struck with the colour and effect presented by the grouping of the strata as being very similar on a larger scale to the roadside section near Drybrook in Dean Forest, and thus we at once hailed old friends in a new locality. At West Angle Bay at the mouth of Milford Haven, the yellow Conglomerates of Caldy Island are wanting, and brown sandstones are intercalated in their place. There is a synclinal in the bay which shows the strata curved on either side. This section should be visited by every lover of physical geology.

Near the section at Skrinkle are the noble ruins of Manorbeer Castle, standing near the junction of the Old Red with the Lower Carboniferous slates. Manorbeer is noted as the birthplace of Giraldus Cambrensis, who describes the Castle in his time as being "excellently well defended by turrets and bulwarks, and situated on a hill extending on the western side towards the sea port, having on the northern and southern sides a fine fish pond under its walls, as conspicuous for its grand appearance as for the depth of its waters, and a beautiful orchard on the same side, enclosed on one part by a vineyard, and on the other by a wood remarkable for the projection of its rocks and the height of its hazel trees. On the right hand of the promontory, between the Castle and the Church, near the site of a very large lake and mill, a rivulet of never failing water flows through a valley, rendered sandy by the violence of the winds." We can readily recognize the site of the lake, mill and vineyard of the home of which the old scholar was so justly proud. The hazel grove on the promontory is there still. The sea washes the Old Red in the "hollow bay" with "inconstant waves and a raging sea," while hard by in the church is the sepulchral effigy of a De Barri cross-legged and sword in hand, in memory it may be of a brother of Giraldus himself.

ORGANIC REMAINS OF THE OLD RED SANDSTONE.

During the latter part of the Silurian epoch, the Ganoid fishes and Placoganoids make their appearance in the rocks. This group of fishes, of which 113 or 114 species have been

PLATE V.



1. Cyathaspis Symondsii. Lankester.
2. Zenaspis Salweyi.
3. Internal cast of Scaphaspis truncatus.
4. Auchenaspis Egertoni.
5. Convex cast of Scaphaspis rectus.
6. Cephalaspis Lyellii
7. Restoration of the Cephalic Shield of Pteraspis Crouchii. Salter.
8. Scales of Pteraspis, attached to a portion of the head-shield. Lankester.
9. Internal cast of Pteraspis Crouchii.
10. Holoptychius nobilissimus.

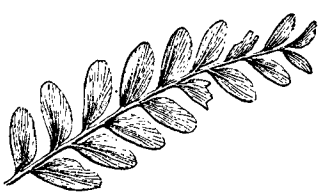
[*Page* 254.

determined from the Old Red and Devonian rocks, were once apparently cosmopolitan, but dwindled away during the Secondary epoch, when they were replaced by other orders. The only remnants now left of this ancient fish fauna, are the Bony Pike of the North American lakes and rivers; the Polypterus of South Africa; and the Ceratodus (mud fish) of Australia. The discovery of the Scaphaspis Ludensis in Lower Ludlow deposits is at present the earliest intimation we possess of the existence of vertebrate life upon the globe. The remains of other genera of Placoganoid fish, or fish protected with plates of enamel, such as Cephalaspis, Pteraspis, and Auchenaspis, have been found in the Passage beds which form a transition series between the Silurian rocks and the Old Red. The spines of some fish, which appear to be allied to the Onchi of the Upper Ludlow bone bed, occur in the Passage beds associated with the plates of Ganoids. The Onchi are generally believed to be the remains of a small shark-like fish allied to the Dog fish (Acanthias).

Sir R. Murchison found that the Cephalaspis-bearing beds of Scotland belong to the Lower division of the Old Red; this is also the case in Siluria, but the species of fish which occur in the Silurian rocks and Passage beds are altogether of different species as compared with those of the Lower Cornstones. The Middle Old Red of the district under review has hitherto supplied no fossils to enable us to determine whether they represent the Osteolepis-bearing strata of Scotland, but the Brownstones occupy the same physical position.

The highest strata of the Upper Old Red furnish the remains of land plants on the Daren near Crickhowell, and Earl Ducie possesses the remains of Calamites and Knorria from beds below the Carboniferous rocks of Tortworth. In Ireland, yellow sandstones occupying a similar stratigraphical position and of similar mineral character, yield in great abundance the beautiful fossil fern Sphenopteris Hibernica, associated with Stigmaria and Knorria, both Carboniferous forms of land plants, and also a shell supposed to be of fresh-water origin, the Anodon Jukesii.

The Upper Old Red of Farlow has furnished the characteristic remains of Pterichthys and Holoptychius, and occupies the same zone of uppermost or transition Old Red strata in Herefordshire, Monmouthshire, and Scotland as that occupied by the Holoptychius-bearing rocks of Scotland and the yellow sandstones of Ireland which yield the Anodon. Mr. Godwin Austen has suggested that the fish of the Old Red Sandstone are freshwater forms like the existing freshwater Ganoids of America; although numerous remains of Old Red fish have



FOSSIL PLANT FROM THE YELLOW SANDSTONE OF IRELAND.

been found associated with marine fossils in Russia and America, and more sparsely in Devonshire and Cornwall. This might be the case, and the fish might nevertheless have been freshwater genera, for freshwater fish must often be swept out to sea by floods. There are two or three facts, however, which appear to me to militate against the idea that the Old Red of Herefordshire may have been a freshwater deposit. We find a number of Eurypteri, Stylonuri, and other forms of crustaceans, which Mr. Woodward believes were *marine*, associated with Lingulæ in the Passage beds, and these crustaceans evidently lived and died in the same waters as the marine Lingulæ. At Rowlestone, Stylonurus occurs high up in the Cornstone series, and Stylonuri occur high up also in the Scotch Old Red, far above at least the Passage beds and Lower Old Reds. Again at Caldy, near Tenby, we have Serpulæ which are marine fossils; and at Farlow, Conularia and other marine forms occur in the Upper Old Red in the same beds with Pterichthys and Holoptychius.

Lastly, I have seen a regular fish bed in the marine Devonian rocks of Cornwall made up almost entirely of the remains of Pteraspidean fishes.

WHYTHALL, NEAR ROSS, OCCUPIED BY OLIVER CROMWELL DURING THE SIEGE OF GOODRICH CASTLE.

CHAPTER VIII.

DEVONIAN ROCKS.

Grouping of the Devonian Rocks and their Equivalent Strata—Porlock—Dunkerry Beacon—Glenthorne—Quantock Hills—M.S. at Crowcombe Court—Cleave Abbey—Lynmouth—Valley of Rocks—Heddon's Mouth—Combe Martin—Fossils at—Morte Slates—Tomb of De Tracey in Morthoe Church—Pickwell Down Grits—Raised Beach at Croyde Bay—St. Branock—Legend of—Sloly Quarries—Fremington—Raised Beach at—South Devon and Cornwall—Looe—Fish Beds of Polperro—Bovey Tracey—Miocene Lake of—Glacial Clay—Kent's Cavern—Submerged Forests—Windmill Hill Cavern—Evidence of Change of Level—Plymouth Limestone—South Cornwall—Granites—Abbey of St. Rumon—Brent Tor—Organic Remains of the Devonian Rocks.

In 1836 Sir Roderick Murchison and Professor Sedgwick discovered that the Culm measures and sandstones of North Devon belonged to the Coal period. They were supported in these views by Mr. Lonsdale, who by his careful investigation of the corals of the Devonian rocks, came to the determination that they belonged to a type which might be considered as intermediate between the Carboniferous and Silurian.

The late Professor Jukes assigned all the Devonian rocks proper, from the Lynton and Lynmouth rocks upwards, to the Lower Carboniferous rocks of Ireland, known as the Carboniferous Slates, Coomhola Grits, and Lower Limestone Shales. Mr. Etheridge, Palæontologist of the Geological Survey of Great Britain, in an admirable résumé of the rocks of Devonshire and their fossils, * gives an elaborate account of the relation of the different Devonian strata to their equivalent marine

* Quart. Geol. Journ., vol. xxiii. 1867.

beds on the continent. Mr. Etheridge considers the whole of the rocks of Devon, including the Dunster and Foreland rocks to be chronologically equivalent to the whole of the Old Red Sandstone; this opinion was also held by Sir R. Murchison.

Mr. T. M. Hall, who is an authority on the geology of his native country, divides the North Devonian rocks into the following zones, viz.,

1. Foreland Group (Base)
2. Lynton Zone
3. Martinhoe Beds
4. Ilfracombe Group
5. Marwood Zone
6. Pilton Beds (Upper Devonians).

Mr. Pengelly has contributed several important papers on the relations existing between the Silurian and Devonian fossils and the Devonian and Carboniferous species.

Dr. Holl of Worcester also published a valuable memoir * on the older rocks of South Devon and East Cornwall, the general results of which are in accordance with the views of Mr. Etheridge.

I have twice carefully examined the Geology of North Devon, more especially the rocks of the beautiful line of coast which trends from Quantock Head to Hartland Point. I studied them when their place in the geological series of rock strata was questioned by Professor Jukes, and at first I came to the conclusion that the Foreland rocks were the equivalents of the Upper Old Red Sandstones of the Brecon and Caermarthen Vans which crossed the Channel into Somersetshire and Devon, and formed the basement beds upon which the slaty rocks of Lynmouth and Lynton rested. I have since changed my opinion and think it more probable that the Dunster, Porlock, Glenthorne, and Foreland rocks occupy the position of the Downton sandstone in the Welsh area and agree with Mr. Etheridge in the opinion that they must be correlated with the bottom rocks of the Lower Old Red Sandstone, or even with the Passage Beds. The paper of Mr. Etheridge, already alluded to, is absolutely necessary

* Quart. Journ. Geol. Soc., Nov., 1868.

to a travelling geologist who would follow out the succession and folds of the North Devon rocks; all I shall attempt to do will be to give some notes of my rambles among them, and point out some localities where they may be seen and studied.

The following table exhibits the grouping of the Rocks of North and South Devon, and some portions of Cornwall.

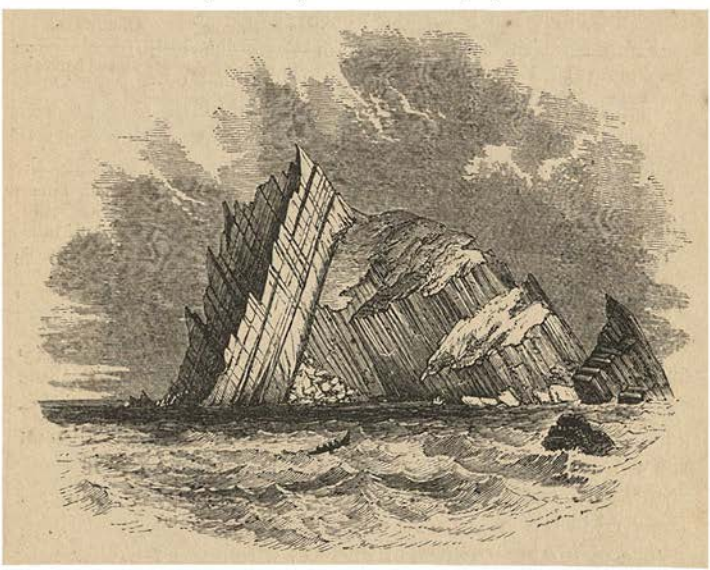
	North Devon.	South Devon.	Cornwall.
Carboniferous Series.	Barnstaple Beds. Carboniferous Series of Sedgwick and Murchison.	Carboniferous Beds.	Carboniferous Series.
Upper Devonian, or Upper Old Red Sandstone.	Pilton, Braunton, Croyde, Marwood, and Baggy Beds, with the Pickwell Down Sandstones at the base (Morte Bay Series).	No representative as yet known in South Devon.	Petherwin Limestones and Slates, Tintagel and De la Bole Slates.
Central or Middle Devonian, Middle Old Red Sandstone.	Mortehoe, Woolacombe, Rockham, and Lee Slates. Ilfracombe and Combe-Martin Slates, Grits, Sandstones, and Limestones. The Hangman and Trentishoe Grits at base.	Dartmouth Slates, Dartington, Ogwell, Torquay, Newton, and Plymouth Limestones, Lummaton and Ramsleigh, &c.	Mounts Bay Slates, Padstow (Hangman Beds)? Porth Towan Slates.
Lower Devonian. Lowest Old Red and Passage Beds.	Heddon's Mouth, Woodabay, Lee, Valley of Rocks, Watersmeet, Lynton, and Lynmouth Slates, &c. The Red Grits and Sandstones of the Foreland, Countesbury, Glenthorn, and Dunster, &c., &c., at the base.	Mudstone Bay Slates near Torbay, Meadsfoot Slates with Phyllolepis concentricus, Yealmpton Creek and Black Hill, &c. &c. Slates, Looe Island.	St. Veep, Polruan, Looe, Polperro, and Fowey Grits and Slates. Bone Bed at Lantivit Bay.

Dunster Basement Devonians, and Foreland Rocks.

The geologist may commence his examination of the Lowest Devonians of West Somerset at Dunster, beginning with the North Hill near Minehead, about three miles distant. Porlock,

Sibyl Head, West Coast of Ireland.

(Sketched by the late Mr. Du Noyer.)



The upper rocks are Upper Devonians resting unconformably against Silurian Rocks.

Culborne and Oare Hills, which overhang the Bristol Channel, are all the rocks of the Foreland rolled from north to south to the North Hill over Minehead, and thus are explained the reversed dips seen here and there along the line of rocks from near Lynmouth to Minehead. At Hurlestone and Greenlay points above Minehead, this rolling is well seen, and there is an inversion of the beds at Hurlestone Point, those to the seaward dipping south-east and the southward beds dipping north-east.

It seems to me that we should never forget that two distinct series of earth movements and faulting have much affected the rocks of Devonshire. The great upheaval of the granite of Dartmoor occured in Post Carboniferous times, and we can hardly judge now of the effect of those upheavals on the rocks, both of North and South Devon, while in North Devon great disturbances again took place in Post Liassic times which in some instances have evidently faulted the beds and changed their dip since the Dartmoor upheaval.

From Minehead the walk from Grabbist Hill to Croydon Hill should by all means be taken, and south of a place called Hopcot, the red sandstones of Grabbist Hill may be seen dipping north and north-east until they reach the valley of Wotton Courtney, where there is a fault along the course of the river and a reversion of dip takes place. Mr. Etheridge found this fault corresponded with that of the St. Decumans fault on to Quantock Head, and that this reversion of dip is traceable to the Foreland, and to Lynton. "It is," he says, "the southern dip of these red sandstones which constitutes them the base of the whole of the superincumbent grits, slates, and limestones of West Somerset and North Devon." The strike of these red basement Devonian rocks is from Timberscombe and Dunster Park to the Foreland and Lynmouth on the west. Hitherto no fossils whatever have been found in these rocks, with the exception of some vegetable remains which I observed in the yellow beds of Countesbury near Lynmouth.

The picturesque village of Porlock, where the traveller may well spend a few days among some of the finest scenery in Somersetshire, is surrounded by a series of hills, all composed of basement Devonian rocks and all dipping from the fault of the Porlock valley towards the sea. This fault along the Porlock valley is supposed to be connected with those Post Liassic movements which have so much disturbed the rocks about Watchet, Quantock's Head and St. Decumans. There are some good sections between West Porlock and Culbone along the cliff road by the sea. The hill of Dunkerry and the ridge of Bossington should both be visited before taking to the

coast. The summit of Dunkerry Beacon commands a noble view, and is the site of ancient beacon fires, which were answered by those on the Welsh Hills opposite, and the distant Malverns. These red sandstones and grits much resemble in mineralogical character, the Upper Old Red series of the Brecon and Caermarthen Vans. I know nothing like them in the Lower Old Reds of the Silurian area. The walk along the coast by Ashley Combe and the small church of Culbone, should be extended to a spot where there is a remarkable erosion of strata into a regular amphitheatre, in which is the "Pet" farm of Lord Lovelace. This amphitheatre is a good example of the effect of streams and subærial decay with the removal of soil by water.

The romantic dell of Glenthorne is only five miles from Lynmouth by the coast path, and the sides of the hills often exhibit sections. A little beyond Glenthorne we come upon an old limekiln which has more than usual interest, for in it were burned, some years ago, several cartloads of the remains of the extinct Mammalia, Rhinoceros, Mammoth, &c., which were imported with Mountain limestone from a fissure at Caldy Island. Portions of teeth, &c., were lying about among the débris when I was there a few years since. The red grits, shillets, and sandstones maintain their character all the way to the Foreland, where, at Countesbury, they pass into yellow beds and the reddish Lynmouth slates of the Tor. These rocks from Porlock Hill to Countesbury form the northern edge of the anticlinal.

THE QUANTOCK HILLS.

As Dunster is the best station for investigating the geology of the Quantock Hills, I may give a few notes of the most interesting localities to visit, although I am strongly of opinion that the basement red grits of Dunster and the Foreland are not exhibited there at all, but are thrown down by the Post Liassic fault of Watchet. After visiting the Trentishoe, Hangman, and Combe Martin districts, and returning again to the Quantocks, I formed the opinion that their red sand-

stones, grits, and shillets, with their limestones, are the equivalents of the Trentishoe, Martinhoe, and Hangman grits, and the Combe Martin limestone, and are altogether higher in the series than are the Foreland and Dunster group of rocks just alluded to.

Visiting the Quantocks, from Dunster, the best route is by Williton, along the northern slope of the hills to Doddington and Quantock Lodge. At Doddington, there is a Keuper quarry of white sandstone, exactly like the Middle Keuper of Pendock and Eldersfield, in Worcestershire, faulted against the Quantock Devonians, and both are upheaved together by the Post Liassic earthquake movements and faulting, of which there is so much evidence in this district. Ashholt Wood, and its quarries of Devonian limestone, are well worth a visit. The limestone contains Devonian corals, and has furnished many pillars, mantel-pieces, &c., for the mansion at Adscombe. The house itself is built of a very remarkable green porphyritic felstone, or trap rock, which penetrates the Devonian beds.

The Cannington limestone at Cannington Park is faulted with slaty beds in a remarkable manner through New Red rocks to the north-east of the Quantocks. The chocolate-coloured slates are like some of the Hangman beds near Combe Martin, and those on the eastern slopes of the Quantock Hills. They are, I imagine, a faulted outlier of the Middle Devonians. Altogether, I do not recommend the district of the Quantock Hills to the student of physical geology. It is too much of an outlier, and is very difficult to work out and to understand without having previously acquired a thorough knowledge of the North Devon beds between Lynton and Ilfracombe. Perhaps the best geological section is to cross the Quantocks from Crowcombe, by Over Stowey and Ashford, to the Cannington limestone.

At Crowcombe Court, Col. Carew directed our attention to a remarkably fine pair of antlers of the red deer (C. tarandus), found in digging a well in marshy ground near the house. And for the Antiquarian a gem of a manuscript of olden times

is preserved in the library. This is an MS. of the gospels in vellum, of a date not later than the eleventh century. At the end of the MS. is a letter addressed to King Alfred by Fulco, Archbishop of Rheims. This Fulco was one of the most eminent ecclesiastics of the day. He was made Abbot of Saint Bertin, A.D. 877, Archbishop of Rheims, 883, and died A.D. 900, having been assassinated by a ruffian hired by Baldwin, Count of Flanders. King Alfred had applied to Fulco for assistance in the attempt he was then making to raise the clergy of England from the state of ignorance and degradation they were then in, by bringing over men of piety and learning from France. Archbishop Fulco approved of the king's design, and the object of the letter at the end of the MS. is to introduce to Alfred a priest named Grimbald, whom he praises highly for his learning and piety. Assur was a monk and companion of Grimbald, and associated with him in the foundation of the university of Oxford. He became bishop of Shireburn and died A.D. 909, leaving behind him a life of Alfred which is of great value as being the work of a contemporary. The best edition of his life was printed at Oxford in 1722 by the Rev. Franc Wise, who has prefixed to it an introduction in which he has published the letter of Fulco to Alfred. This fine MS. was adorned originally by some full page illustrations representing the four Evangelists and the same number of full paged initial letters, but those prefixed to the Gospel of St. Luke have been abstracted. These are the finest examples of the art of the period and in clear, bright excellence of condition cannot be excelled. The MS. is in the original oak binding.

Between Williton and Dunster the road passes by a picturesque ruin, Cleave Abbey. It is in a state of lamentable neglect, dovetailed into a farmhouse, the barns of which are formed out of the old ecclesiastical buildings. The chapel has been replaced by cowsheds, and barns and granaries usurp the place of dormitories and refectories; while the cloister is appropriated to still fouler purposes. The refectory is a noble apartment full fifty-six feet long, with a fine vaulted roof of

carved oak, and still in good preservation, with wall springers representing angels resting on corbels. At the east end is a large painting in distemper representing the crucifixion. The dormitory is seventy feet long. This Abbey is reported to have been founded in the twelfth century. The earliest portions now existing do not apparently date back much beyond the middle of the thirteenth century, but the structure appears to have undergone extensive alterations late in the fifteenth century, to which period all the upper portions of the building, including the windows, etc., of the refectories, appear to belong.

Lynmouth and Lynton are situated on the outskirts of Exmoor, amid scenery celebrated by Southey, and among geology difficult enough to puzzle the most accomplished explorer of physical phenomena. Walking up from Lynmouth (which village I recommend as a residence while studying the geology of this district) by Countesbury Hill, we pass over grey and pink slaty beds of great thickness, and these as far as we can judge, are *underlaid* by yellow sandstones which are seen close to Countesbury Church and these again pass into the Old Red Sandstone looking grits of the Foreland series. It is well to examine these basement beds up the coast to Glenthorne. At Countesbury the yellow sandstones contain impressions of plants and would repay working for fossils.

Starting from Lynmouth up the Lyn, the slates on the side of the road to Watersmeet are fossiliferous. East of the river the beds are much arched and folded, but the junction between the yellow Countesbury beds and the Lynton and Lynmouth slaty and fossiliferous rocks, may be traced between the Tors and Countesbury Church. The lover of physical geology will do well to follow up the rock sections on the east side of the river Lyn, for about five miles, to a bridge near a place marked Barton on the Ordnance Map, and then crossing by a bridge one of the tributaries of the Lyn, to return to Lynmouth by the western bank, west of the Lyn. The strata which are so arched, faulted and rolled on the east bank of the E. Lyn, appear again on the west bank, but are more horizontal and

dipping to the south. The rocks at Watersmeet afford fossils,* the most typical forms are Orthis arcuata, and Chonetes sordida. The "Steganodictyum" of McCoy (which has since proved to be the cancellated structure of the Old Red fish, Pteraspis or Scaphaspis), is not uncommon.

The Lyn cliff should be ascended from Watersmeet, not only for the sake of the scramble and the beauty of the view, but for an especial bird's eye look at the surrounding country, Countesbury and its Church and the yellow sandstones on which it stands, with the red rocks of the Foreland come into view, and, knowing their position and mineralogical character, let the geologist walk on to the escarpment above the Devil's Cheesewring. This escarpment is composed of red, grey and yellow grits and sandstones, which also constitute the table-land above Lynton, and which are enough to puzzle his Satanic majesty himself, for they are precisely similar to the rocks of Countesbury and the Foreland, and appear to be a repetition of the Foreland and Countesbury beds, caused by the anticlinal of the Lyn valley. This would be the general reading, especially in the absence of fossils, but Mr. Etheridge, who has paid much attention to these Devil's own grits, assures me that they have positively *no correlation whatever* with the Foreland rocks, but are a higher and succeeding series of red grits and yellow sandstones which rest above the Lynton and Lynmouth slates, and which underlie at Trentishoe and Martinhoe, the Combe-Martin and Ilfracombe series. Descending from the escarpment above the Cheesewring, we come upon the remarkable scene of the Valley of Rocks, where crags and pinnacles stand out in strange confusion, the effect of sub-aerial denudation and weathering along the planes of bedding. The Castle Rock faces the Devil's Cheesewring and is situated on crags which overhang the sea. It looks wonderfully like a Norman fortress falling into ruins and decay. "Ragged Jack" and the "Chimney Rock," were once conterminous with the strata on the hill sides opposite before the Valley of Rocks had a beginning. I have knocked out fossils from the "steps" of

* They are collected by the man who looks after the road.

the Castle Rock. Two kinds of Orthides, and Spirifer lævicosta occur there.

Mr. Etheridge has traced the succession and physical changes of these rocks along their river gorges of the East and West Lyns and also along their different exposures by roadside sections. The coast-line sections are more easy to follow out than those in the interior of the country, the scenery too is far more beautiful and the inhabitants are more courteous. The cliffs, and rock escarpments a short distance inland; the richly wooded heights; the combes and rushing rivers; the crags and heathery slopes; and the coast towns and villages are beautiful exceedingly.

Leaving the Valley of Rocks, the geologist may descend to the beach at Woodabay, and observe the Lynton slates with fossils dipping to the south, and then ascend the hill to Martinhoe. In a quarry about four hundred feet above Woodabay, Sir Wm. Guise and I noted slaty beds similar to those in the Valley of Rocks, and at a quarry above Slattendale, come in pinkish grey slates, strongly resembling those of the Upper Lynmouth series by the Tors, and these pass into red grits and sandstones surmounted by yellow sandstones. The Yellow beds occur in the road near Martinhoe Church, and again in a quarry from which large blocks were being raised for the repairs of the church when we were there in 1868. It would seem that these Martinhoe red sandstones, grits, and yellow sandstones must be correlated with those above the Devil's Cheesewring, as they also overlie the Upper Lynton and Lynmouth beds with fossils, and are also similar in mineralogical character to the Countesbury and Foreland rocks. About a mile beyond Martinhoe the road leads into a deep combe which opens seaward at Heddon's Mouth. Here in a sequestered glen is a lone cottage known as "The Hunter's Inn," where a geologist may stay, and from whence he may visit the coast sections in a boat. There is a section at the mouth of the Heddon, at the base of which are the Lower Devonian slates. It is similar to the Woodabay section. A bright red Sedum grows on the cliffs, and in the fissures are fine fronds of

Asplenium marinum. There is a ghost too at "Sir Robert's road," who the boatmen often hear sighing round Heddon's Mouth and who "walks" by the side of the stream on moonlight nights to such an extent as to frighten many a poacher of the Suen (Salmo alba) a fish which ascends this stream in the autumn. Altogether it is a strange weird place.

Ascending the hill up to Trentishoe Church we observe the Upper Lynton rocks passing upwards into Martinhoe slates, like those eastward at Slattendale; and in the road beyond Trentishoe Church the yellow beds occur and are traceable on their strike for some distance. Thus the churches of Countesbury, Martinhoe, and Trentishoe all stand on yellow sandstones. The highest part of the road passes below Trentishoe Barrow, which is nearly 1200 feet above the sea. We questioned here whether the terminal Hoe, which is attached to so many of these headlands, may not be synonymous with How, a term applied, in the north of Scotland, to a barrow and believed to be of Scandinavian origin. Both in Devonshire and Cornwall such prominent situations appear to have been selected for the interment of chiefs, or men of renown, of ancient races, of whom we know nothing, save their burnt ashes, rude pottery, and flint chips.

The trailing Club moss (Lycopodium clavatum) grows on the hills between Trentishoe Barrow and the glen of Shercombe, and reminds us, in its seed vessels, of the old Silurian land plant that has left its globular spores among the remains of the Scaphaspis, vestiges of which we hoped to find in the Devonian yellow beds. Shercombe Dingle furnishes the Bog pimpernel (Anagallis tenella) and Chrysosplenium alternifolium, while some of the Hangman fossils are known to occur among its loose stones, but we did not succeed in finding them here *in situ*.

Always bearing in mind that the rocks dip on their strike seaward and westward, we find the Martinhoe, Trentishoe, and Great Hangman red grits are overlaid by the red fine grained sandstones and slaty rocks of the Little Hangman. Having thoroughly examined the rocks of this district, in a boat along

the coast, as well as inland, I read their succession as follows:—

Middle Devonians.
Combe Martin limestones.
Satiny slates.
A volcanic Ash and Trap intercalated.
Hangman Conglomerates, with red and yellow sandy rocks.
Hangman fossiliferous beds, containing Natica, &c.
Grits.
Trentishoe and Great Hangman grits.
Martinhoe and Trentishoe grits.
Lower Devonian Slates, the Bottom rocks at Heddon's Mouth.

MIDDLE DEVONIANS.

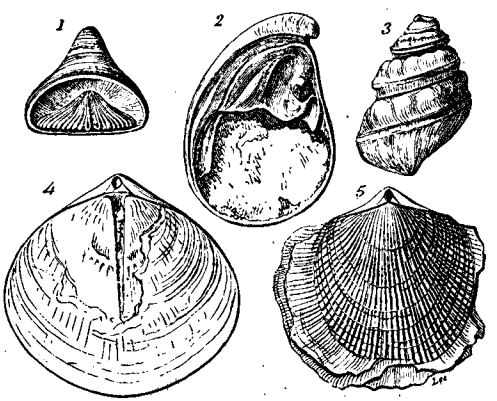
It is not possible to examine the Combe Martin district properly without sojourning awhile in the immediate neighbourhood. The little town itself is long and irregular, with an interesting Church and a fine perpendicular tower. There is good sea fishing off the cliffs, and it is by far the best locality in North Devon for collecting the fossils of the Middle Devonians, while the botanist cannot fail to obtain many interesting plants; amongst them he may see the green Laver of the epicure collected in great quantities; it is preserved for winter consumption.

Under the Little Hangman I obtained a number of well-preserved fossils in red grits; *in situ*, they occur about half way up the cliff, and fall in masses on the shore. Among them were Stringocephalus Burtini, Naticæ, and large Myalinæ. The junction of these beds runs up the road from Combe Martin to Knap Down Mine, but the plan to obtain good fossils is to take a boat and land under the cliffs.

Boating from Combe Martin round the Point, we see a decomposing volcanic rock traversing the slates. I could not make out whether it was a contemporaneously bedded trap, or an erupted dyke, but I expect it is the former weathering on its edges. Rounding the Headland, a red and yellow conglomerate is seen to lie between the satiny slates and the fossiliferous red rocks of the Little Hangman. A cliff path, called the Miner's Path, leads from the beach up to the summit of the

cliff, from whence the explorer may walk back to Combe Martin. Some good plants flourish on the Little Hangman cliffs, and report says that the Maiden Hair fern (Adiantum Capillus Veneris) grows here in one or two localities. At all events, my boatman pointed out a light green streak which he declared was this much coveted botanical treasure. When I

FOSSILS OF THE MIDDLE DEVONIAN LIMESTONES.



1. Calceola* sandalina, Lin. 2. Megalodon cucullatus, Sow. 3. Murchisonia bilineata, Goldf. 4. Stringocephalus Burtini, Def. 5. Atrypa desquamata, Sow.

was last at Combe Martin, there was a good section on the road between the town and Watermouth, in the limestone and slaty rocks that pass into the Ilfracombe group. Numerous Devonian corals have been found in these beds, with trilobites and the Silurian shell Atrypa reticularis.

"It is these limestones," says Mr. Etheridge, "which so eminently characterise the Middle Devonians, and, as on the continent, contain that peculiar group of corals totally unlike and different from those of the underlying Silurian rocks as well as, without exception, the Carboniferous; for of the fifty species of coral known as the Middle Devonian series of North and South Devon and Cornwall, one doubtful species only is said to occur in the Silurian rocks, viz., Favosites fibrosa, and

only one is said to pass up into the Carboniferous series, viz., Amplexus tortuosus, of which, however, we have no authentic evidence."

The geologist cannot do better than follow the rocks by the coast series from the bay at Combe Martin to Ilfracombe, as they are far easier to read off there than inland. Hagginton Hill quarry is famous for its fossils. They include Atrypa reticularis, Rhynconella pleurodon, and Spirifers of several species. Fossils may be found at the headland of Helesborough. Mr. Valpy, a gentleman who geologised the Ilfracombe district, obtained many specimens from the Helesborough beds. Among them are some fish spines. I saw a small ichthyodorulite in some silicious beds, but unluckily broke it with the hammer. There are numerous brachiopods, but they are badly preserved; indeed I never obtained a well defined fossil from this headland.

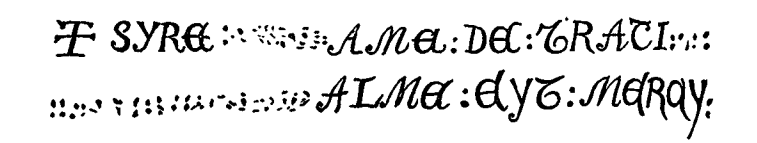
A visit should be made from Ilfracombe to Muddiford, to examine the volcanic rock which is poured over the Morte slates and apparently bedded with them. It consists of a greenish felstone porphyry. Another igneous rock occurs in the coast section near Rockham, between Ilfracombe and Morthoe; it may be seen by crossing the little river to the rocks at the mouth of the stream. This Trap is not on the same horizon as the Muddiford or Bittadore porphyry, for that porphyry is nearer the junction of the Morte slates with the red sandstones by which they are overlaid at Swinham Down and Pickwell Down.

At Rockham Bay, the Devonian Morte slates are traversed by a number of quartz veins, the result of fracture and segregation of the quartzite in the fissures. The slates are much folded, and when in a boat off Bull Point I observed a rock which looked like a dyke elevating the slates at a high angle, but I was unable to land and examine it *in situ*. These quartz veins are useful to the geologist through N. Devon, as indicating the horizon of the Morte slates, which are unfossiliferous. I have several times traced the coast section from Ilfracombe by the Valley of Lee, Rockham, and Morthoe to the

Woolacombe sands, but never found a fossil. The geologist may stay at the Barricane Inn when engaged in working out the Morte slates, and the mooted question as to whether there is unconformity between the Morthoe and Woolacombe slates and the overlying sandstones of Pickwell Down, Potter's Hill and Croscombe. This may be done by carefully observing the dip of the Morte slates from Morthoe past the Barricane beach, (where the beautiful blue Ianthina of the Mediterranean may sometimes be found living among the shells) to the place where they abut against the Woolacombe sands, and where they show signs of having their dip reversed. Not quite half way across the sands is a stream of water which flows under Potter's Hill, and this stream occupies *a line of fault*, the Morte beds consisting of dark slates and bands of quartz, with a nearly vertical dip, being thrown off at an angle in a direction opposite to the Pickwell Down beds. I think there is here, distinctly traceable, a line of fracture between the Pickwell Down beds and the Morte slates, and that this fracture runs between the same beds at Liddon Hill near Dulverton, many miles to the eastward. Nevertheless, as the Pickwell Down beds are seen above Ventian dipping at an angle which would carry them far over the Morte slates, the fault at Woolacombe may not interfere with the regular succession.

The church at Morthoe has "been done up," as we were assured at Barricane Inn, and for an old church is as much "done for" as new masonry, a new pulpit, and new stained-glass windows can make it, but happily the beautiful carved benches were spared, and the tomb of the Tracey. The latter is indeed a beautiful monument and well worthy of note. On an altar tomb of white stone, adorned with architectural work, and niches, with figures a good deal dilapidated, but of early thirteenth-century workmanship, rests a slab of black Purbeck stone on which is an incised effigy of a man, apparently in the garb of a priest, holding in his hand the sacramental cup. The features are entirely obliterated, but on the head the outline of a peculiar cap, not unlike a coronet, is plainly traceable. Round the west and south sides of the

slab the following inscription is visible, as traced by Sir William Guise,—



which may be read thus—"Syre Guillame de Traci git ici Deu de sa alme cyt mercy." Sir William de Tracy lies here: may God on his soul have mercy! That this is the memorial of the bold slayer of Beckett may well be doubted, as the priestly habiliments and the cup of blessing are not emblematic of him; but tradition has it that he was long in hiding in these parts, where his family had possessions—which is very probable. Any way the effigy is one of great interest, and cannot, I believe, be of later date than early in the thirteenth century.

From a book called "Memorials of Barnstaple," which we met with at the residence of the Rev. Mr. Hall, of Pilton, we made the following extracts. "In the church of this place is a handsome monument said to have been made the depository of the remains of De Tracy, Beckett's murderer, but more generally believed to be that of a clergyman named William Tracy, who died at Morte in 1322, and who, as the title of Sir or Syre was commonly applied to the clergy at that period, had it inscribed on his tomb as a customary thing. The northern side is occupied by some armorial bearings, consisting of three escutcheons: one containing three lions passant gardant, a second three bends, and the third a Saltire."

Close by the Church is a Mortuary for the reception of those bodies which the sea throws up only too frequently on this dangerous coast. In the winter few weeks pass without tenants for this sad receptacle. At Morthoe I recommend the geologist to obtain a boat and examine the cliff sections (on a fine day!) off Bull Point. There are dykes of igneous rock in the slates, as well as bedded masses of a volcanic conglomerate; and the rock fissures are full of beautiful ferns in the summer time, which are almost eradicated by the eternal fern destroyers

in the neighbourhood of Ilfracombe. Here also I saw a Peregrine Falcon, which bred there in 1868; the young birds were sent for hawking purposes to Oxfordshire.

The Middle Devonian rocks from the Little Hangman and Combe Martin to the base of the Pickell Down beds beyond Morthoe, are believed to be the representatives of the great coralline limestones of Plymouth and Torbay, which have furnished so many beautiful specimens to the museum of Mr. Vicary, and also of the Eifel limestone of the continent. The Calceola schiefer is found in South Devon; and the Stringocephalus Burtini of Combe Martin is so abundant in the Rhenish Devonians as to give its name to a limestone.

UPPER DEVONIANS.

Taking the coast sections in North Devon, the Pickwell purple slates and sandstones may be seen in a quarry at the foot of Woolacombe Hill dipping slightly to the south, but nearly vertical. We ascended Potter's Hill and Pickwell Down, going down again to the shore at Ventian. From here the explorer may boat round Baggy Point, see the cave, and obtain a view of the Headland and its coloured rocks. From here we have as follows:—

	Organic Remains.
3. Pilton and Barnstaple Beds. Sandy slates and schists, dark rocks.	Avicula Damnoniensis, Strophalosia caperata, Spirifers. Producti, and the bivalves Curtonotus, and Modiola.
2. Baggy Point. Marwood and Sloly rocks, very fossiliferous.	Cucullæa trapæziani, abundant. Avicula Damnoniensis. Lingula Mola. *Plants.*—Bornia and Knorria.
1. Pickwell Down. Grits, &c.	No fossils known.

The Pickwell Down red grits pass up into a series of pale slaty beds and conglomerates as seen along the coast section between Ventian and Baggy Point; and from the grey slaty beds I possess a portion of the stem of Knorria, or Bornia, similar to those found at Marwood by the Rev. Mr. Mules. These slaty strata pass into a thick series of yellowish and

grey shales, sandstones and thin limestones full of fossils, with vast numbers of Cucullææ and Aviculæ in beds which crop out on the summit of the hill of Baggy Point. As I write I have before me a drawer full of beautiful fossils which I have obtained at different times from Baggy Point, Braunton, and Marwood. Lingula Mola occurs on the beach at Baggy Point, and, *in situ*, is below the Cucullæa bands. It is named after the Rev. Mr. Mules, whom I have to thank for much local information. Above the Baggy and Marwood beds, set in the grey slates and calcareous sandstones of the Pilton group, I had the advantage of seeing these rocks with Mr. Townshend Hall, and obtained, under his guidance, some of the typical fossils. On the cliffs between Baggy Point and Croyde Bay, Mr. Hall discovered some worked flint implements with coarse sun-baked pottery, near a small stream flowing to the sea. A short search rewarded us with several flakes and a good core, still in my possession. It seems as if there had been a manufactory of these flints near where they are now found, as no flint is known within sixteen miles of the spot. The Drift, which is an atmospheric wash, rests on the coast in some thickness on the dark, slaty, Devonian rocks, in which occurs in some abundance Rhynconella laticosta, contorted by slaty cleavage. Near this locality are also patches of a raised beach, lying nearly horizontally on the slates which dip at a sharp angle. They contain the Mytillus of our present seas, Purpura lapillus, and other shells. At Saunton, near Braunton, there are two beaches; the lower beach, on which the upper one rests, is cemented in layers, and they both contain rounded pebbles and numerous shells.

The Rev. D. Williams, in his paper "On the Croyde Raised Beach," * describes a large block of granite which was resting directly on the fundamental slates, and covered and imbedded by the base of the beach. It is a true erratic boulder, but comes only from Lundy Island to the westward.

Braunton Burrows is celebrated for its rare plants, and especially for a rare euphorbia and geranium. It is said to

* It can be best reached from Braunton.

derive its name from St. Branock, an Italian, who came to England A.D. 300. Leland, in his "Itinerary," speaks of a window in the church, in which were represented St. Branock's cow, his staff, his oak, his well, and his servant, Abel. The window has disappeared, but on one of the panels of the roof is a sow with a litter of pigs, in allusion to a legend that St. Branock was directed in a dream to build a church wherever he should first meet a sow and her family. Hence the church!

The Rev. Mr. Mules was my guide from Muddiford to Barnstaple, where sections may be traced from the Pickwell Down beds of the coast through the Baggy (Marwood and Sloly beds) rocks to the overlying Pilton rocks. The quarries at Sloly have furnished many plants, such as Knorria, a species found in the Upper Old Red of Ireland and England, and Bornia, associated with Cucullææ, Lingula, Orthoceras, and Bellerophon. Between Sloly and Barnstaple the Pilton beds succeed the Marwood group in ascending order; but neither here nor on the coast was I satisfied that they were conformable. At all events the Pilton rocks are rolled and troughed to a great extent about Ashford; and off the coast at Baggy Point the Cucullæa beds do not conform in their southward dip to the Pilton group, which appears to be faulted against them. Such at least was my impression. At Orchard quarry near Pilton, Mr. Townshend Hall obtained numbers of typical Devonian fossils, such as Spirifer disjuncta, Athyris concentrica, and Curtonotus unio (Salter), a species of bivalve found in the Old Red Passage beds in Pembrokeshire and Ireland. I am not aware that there is any section south of Barnstaple showing the succession of the Carboniferous rocks to the Pilton group; but Pilton rocks and fossils are found at Ashford Strand, rolled and faulted, and also at the railway station, south of the river. It is, I believe, Mr. Hall's opinion that the Carboniferous shales lie *in troughs* of the contorted and twisted Upper Devonians, or Pilton group. At Fremington there are Mountain Limestone fossils; and Millstone grit comes on on Coddon Hill. This hill rises to the height of 630 feet above the river; it is a good site wherefrom to survey the

neighbourhood and the rocks, which rise from underneath the Millstone grit northwards and eastward. Near Coddon Hill was the birthplace of Gay, the poet.

Barnstaple is a good place to stay at to obtain a collection of fossils, and while carrying on the intricate study of the Upper Devonians. I found the only way of satisfying oneself at all as to the correlation of the rocks, was to take the coast sections in detail, and then, armed with Mr. Etheridge's paper* already quoted, to take the inland sections.

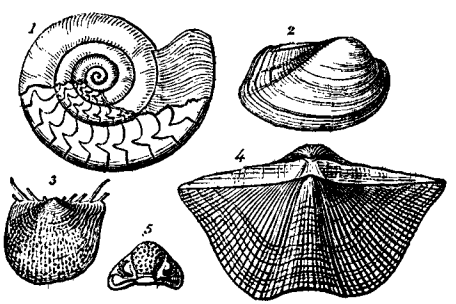
Fremington, with its deposit of clay, lies three miles to the south-west of Barnstaple. Mr. Maw† carefully examined this formation in 1863, and since that time I have paid some attention to it. It rests on a shingly gravel, the Fremington raised beach of Sir H. de la Beche; this ancient beach is probably of the same age as the deposition of the granite boulder of Croyde Bay, which, as before described, rests on Devonian slates, and is covered by the hard sandy layers of the lower raised beach. I imagine that the Fremington beach is older than either of the Croyde beaches. It has furnished no shells, and is covered by a till, or clay, which, as Mr. Maw has shown, contained a true erratic boulder at the hamlet of Combrew. This erratic is composed of basalt, and was imbedded in the clay itself. The Fremington clay occupies a height of 110 or 120 feet. It may be a glacial till like that of Bovey Tracey, which there covers the Middle Tertiary lignite, and which afforded arctic plants such as Betula nana and Salix herbacea, to the researches of Mr. Pengelly. As regards the question of the *submergence of Devonshire during the glacial period*, I must confess I have never seen any evidence whatever of such submergence, with the exception of certain low-lying lands which skirt the country. On the contrary, there is an extraordinary deficiency of anything like erratics in the interior, as compared with most other parts of England.

I do not recommend the cross sections of North Devon in the interior of the country, to anyone who is not an ardent lover of physical geology for its own sake. The fossils are con-

* Quart. Journ. Geol. Soc., vol. xxiii., 1867. † Quart. Journ., Nov., 1864.

fined to a few localities, not easy to find, and the faults and unfossiliferous quarries are manifold. Nevertheless, to those who have studied the coast sections, the traverses from Dunster to Dulverton, and across the country from the basement beds of Glenthorne, by Paracombe and Challacombe to Barnstaple and on to Bideford, are very instructive, while it is hardly possible to understand Mr. Etheridge's conclusions without following out some of his routes across the country. It was owing to my having worked out some of these sections, that I became myself convinced that the series of Devonian rocks as a whole group must be more or less the chronological equivalents of the Old Red Sandstone of the Silurian area, but deposited under different conditions as regards animal life and in a different geographical area.

FOSSILS OF THE UPPER DEVONIANS.



1. Clymenia undulata, Münst. 2. Cucullæa Hardingii, Sow. 3. Strophalosia caperata, Sow. 4. Spirifer disjunctus, Sow. (Verneuilii, Murch.). 5. Phacops granulatus, Münst.

SOUTH DEVON AND CORNWALL.

During the last few summers I have examined some of the typical sections of South Devon and Cornwall for the purpose of satisfying myself with respect to their co-ordination and correlation with the rocks of North Devon.

Many of the difficulties which long shrouded these rocks had been dispelled by the discoveries of Murchison and Sedgwick, De la Beche and Godwin Austen. Nevertheless I found the

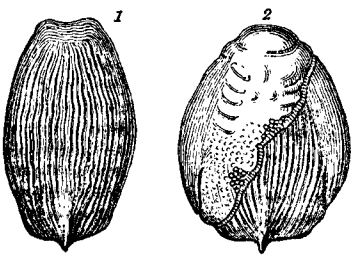
relations of the South Devon rocks, when compared with those of West Somerset and North Devon, very difficult to understand, and I believe that their correlation is not yet established; while the regular succession of the rocks of Cornwall still remains to be unravelled. An exhaustive paper by my friend Dr. Harvey B. Holl was published in the Quarterly Journal of the Geological Society for 1868, "On the older Rocks of South Devon and East Cornwall," but he did not attempt the co-ordination of the rocks of the South with those of the North; and contented himself with a most valuable and closely written résumé of the order of succession in South Devon and Cornwall.

The few notes I shall contribute to the subject must be regarded as merely supplementary; the object being to furnish the amateur and wanderer, among the rocks, with a few hints from my own endeavours to make out their succession and correlation in this intricate country.

The remains of fossil fishes were found by the late Mr. Couch of Polperro, and were described by Mr. Peach in 1846 in the Transactions * of the Royal Geological Society of Cornwall; the rocks in which they were discovered were described by Murchison and Sedgwick. † The fish remains however were supposed by Professor McCoy to be the remains of fossil sponges, and as such were named by him "Steganodictyum Cornubicum," and even now these relics go by the name of "Polperro sponges." In 1868, when on a visit to Torquay, I was examining the collection of my friend Mr. Pengelly, in the company of Mr. Leonard Lyell and Mr. R. M. Lingwood, and at once identified the structure of Steganodictyum with that of the Old Red and Silurian fish Pteraspis. This identification was afterwards confirmed by Professor Huxley and Mr. Ray Lankester. This identification of the genus Pteraspis or Scaphaspis in the Devonian rocks had an important signification as regards their age, especially as the remains of the same "Steganodictyum" had been detected by Mr. Etheridge in the Lower Devonians of Lynton and Lynmouth.

* Vol. vi., p. 79. † New Series Trans. Geol. Soc., vol. v.

When in Cornwall, therefore, during the early part of this year, (1872) I endeavoured to make out the position of the fish-bearing rocks, and I have little doubt that they belong to the Lynton and Lynmouth group of North Devonshire, possibly to the upper portion of that group.



1. Pteraspis truncatus. 2. C. Banksii.

To illustrate the structure of Pteraspis, Scaphaspis, and Cyathaspis, as found in the Lower Devonians of North Devon and Cornwall.

LOWER DEVONIANS OF SOUTH DEVON AND CORNWALL.

From Torquay the geologist will probably visit Brixham and Berry Head. Let him extend his walk to Mudstone Bay, a pleasant coast ramble W. of Berry Head.* Here he will see a series of Silurian-looking shales faulted against the Plymouth and Middle Devonian Limestones. Mr. Pengelly has found the remains of fish in these faulted rocks, and in mineralogical structure they greatly resemble some of the Lynton and Lynmouth slaty beds of North Devon. These rocks cross the river Dart, and run by Cornworthy westward in an anticlinal axis. I think that if well examined they would yield fossils, but hitherto hardly any have been found.

At Cornworthy, four miles south of Totnes, are the ruins of the Church of Cornworthy Priory, and an old gateway; these are the only relics of a monastery founded in the 14th century. There is also a most interesting church at Harberton, three miles to the north-westward, remarkable for its pulpit, fine screen, and a wood loft.

* From here he may return by a short cross-country path to Brixham.

At Meadfoot sands, a little west of Torquay, are some strata which are supposed to be Lower Devonian. They resemble the beds of Whitesand Bay in the Looe district, which I believe are *higher* than the fish bed of Looe, Polperro, and Lantirit Bay. In both localities they contain Pleurodictyum problematicum, Athyris concentrica, Orthis hipparionyx, Bellerophon bisulcatus, which occur in the Middle Devonians of North Devon. In the cliff between Meadfoot sands and the Thatchen rock, Mr. Pengelly found scales of an Old Red fish, Phyllolepis concentricus, and another scale of a similar fish is figured by Professor Phillips as belonging to Holoptychius.

When in the Plymouth district Whitesand Bay should be examined. This may be done by crossing the water to Anthony, and going by St. John's to the coast. Rame Head is the termination of a range of cliffs which form a semicircle between Polperro and Rame Head. Maker Heights rise upwards of 400 feet above the sea, and the Church was a signal station during the French war on account of its commanding position. Descending to the shore, the geologist may work out the cliff sections from below West Maker to East Looe. It is my impression *that the Looe fish-bearing beds are faulted against the strata of Whitesand Bay and cannot be correlated with them.* In elucidation of this difficult question Mr. Pengelly says: "The key to the succession of beds about Polperro, Pencarrow Head, &c., is to be seen in the cliff about a mile to the west of my native place Looe." "In passing from Liskeard to Looe we have a continuous ascending series, which is continued beyond the latter place to Port-Nadler, the spot in the cliff just mentioned. Here there is a synclinal axis, and beyond, that is south-west of it, we get, by continuing along the coast, an entire reversal of dip, and successively lower and lower beds, instead of as before, higher and higher. In short we get beds we had passed between Looe and Port-Nadler repeated. The bone bed is directly above the Pleurodictyum Slates and directly below the Plymouth Limestones; *i. e.* the place of the Slates of Mudstone Bay, in which I have also found the Polperro fish.

If, however, there is not a great fault in Whitesand Bay, by which the lower slates are brought up again at the Rame Head, the fish remains must occupy the slates above the limestones as well as those below them."

What between a fault from Bodmin by Lostwithiel; another cross fault by Gribbin; a synclinal at Looe river; and an apparition of red rocks at the mouth of the river Seaton; the geologist will probably find the problem of their correlation attended with considerable difficulty!

The little town of Looe* is well worth a visit from every lover of the picturesque. The view from the sea side shows a series of dark Devonian cliffs, and in front is Looe Island, nearly 200 feet in height. Inland, considerable hills rise above the little estuary, and the Devonian slates are dipping as if from some upheaval out at sea. The inversion of the strata may be seen in Pottledler Bay, opposite Looe Island, and may be traced inland and westward along the coast to Pencarrow Head, beyond Fowey Haven. Middle Devonian fossils have been found in Red rocks on West Looe Down, and these beds are *not conformable* to the Looe fish-bearing strata. Scales and plates of Pteraspis, and some ichthyodorulites, have been detected at Gribbon near Menabilly, and at Mellendreath beyond East Looe. I expect that these beds are higher than the Lantirit bone bed.

The walk from Looe to Polperro is interesting. Boating by the cliffs in fine weather is better still, and all along the coast the Devonian fish-bearing rocks may be seen dipping *inland*, whereas, as a rule, and away from local Trap upheavals, the rocks of the southern coast of Cornwall dip away, from the granite of the interior, towards the sea. Polperro is an ancient place, mentioned by Leland "as a fishar towne with a peere," and few places I have ever seen have struck me more than the nestling beauty of this old haunt of Cornish smugglers. Let me recommend the clean little hotel of "The Ship" to any brother of the hammer who loves the lore of the rocks, sea

* The quickest way of reaching Looe is by rail from Plymouth to Liskeard, from whence it is a nine miles' drive.

fishing, and romantic scenery. Polperro was long the home of a Cornish naturalist, Mr. Couch, well known for his work on "British Fishes," and who was the first to discover the remains of fossil fish at Scilly Cove, on the east side of Polperro harbour, where he pointed them out in situ to Mr. Peach. At Polperro, whither I was accompanied by Sir W. Guise, we made the acquaintance of Mr. Loughrin, formerly of the Coast Guard Service, and a good naturalist, who has accompanied Dr. Carpenter and Mr. Gwyn Jeffreys on more than one of their deep-sea dredging explorations. Mr. Loughrin has a good collection of local fish, and crustacea, well arranged in a little museum, and he is acquainted with the botany of the district. Polperro Ichthyolites are found under the Signal station, and in other spots east and west of the village; but Mr. Loughrin was good enough to conduct us to a locality some distance from Polperro, where he showed us the fish bed *in situ*. The rocks dip at a high angle, and are covered by the sea at high tides. This fish bed appears to be underlaid by a series of red and yellowish slaty rocks, which it is not impossible may prove to be the eroded edges of the Foreland beds of North Devon, which underlie the Lynton slates that contain remains of Scaphaspis and Pteraspis. As far as I could read the geology, the Lantirit and Polperro rocks lie at the base of the exposed Cornish Devonian strata, and both these basement Devonian and the Lower Silurian (Caradoc) rocks of Gorran Haven, Caerhayes, and Gerrans Bay have, I expect, been faulted and upheaved *since the intrusion* of the Dartmoor and Cornish granites, which has so generally affected the rocks of Cornwall, and which is now ascertained to have been post-Carboniferous. In the Museum of the Royal Geological Society of Cornwall, at Penzance, are some specimens of the remains of Pteraspis or Scaphaspis, and some fragments of icthyodorulites, presented by Mr. Peach and Mr. Couch, also some Caradoc fossils (not Upper Llandovery as generally supposed) from Gorrans Haven; but a few geologists under the guidance of Mr. Loughrin at Polperro, would soon obtain far finer specimens than any now in the Museum, and would do

good service, it might be, in finding other fossils typical of the Lowest Devonian rocks.*

To the best of my judgment the Red rocks on the north of St. Veep, which overlie the fish-bearing slates, are unconformable to them. These reddish rocks may be the equivalents of those Trentishoe and Hangman strata of North Devon which lie below the Combe Martin limestones. Working northward from the Looe coast to St. German's and Saltash, there come on a series of fossiliferous slates with interbedded volcanic ashes and intruded masses of volcanic rock, as may be seen close to the station at St. German's. These, I imagine, again overlie the red slates and grits which succeed to the north of St. Veep and Looe (Hangman beds?) and which pass upwards into limestones (Combe Martin beds?). Again, if I read the problem aright, the Pteraspis beds of Looe underlie the Red rocks of Talland and Lansalloe, which again pass under and underlie the St. German's slates and limestones.

MIDDLE DEVONIAN ROCKS OF SOUTH DEVON.

Whatever may be the relation of the Lower Devonians of South Devon to the Lower Devonians of North Devon, there can be no doubt concerning the position of the great group of the Plymouth and Torbay limestone, as may be seen by consulting Mr. Etheridge's list of the numbers of marine animals whose fossil remains are found both in the North and South Devon limestones, notwithstanding the great excess of workable limestone in the southern area.

In 1868 I took up my quarters at Exeter for some weeks to pursue the study of the South Devon rocks, coming to them fresh from the examination of the North Devon series. I cannot pass on without acknowledging the information I received from Mr. Vicary of Exeter, and Mr. Pengelly of Torquay. The museum of the former gentleman in Colyton Crescent is a fine collection of Devonian fossils, and admission to it is a great

* I wish here to record the courtesy I received, when visiting Penzance, from the Hon. Secretary and Hon. Curator of the Museum—E. Batten, Esq., and Miss Carne.

boon to the passing amateur, who cannot expect to collect sufficient typical fossils to enable him to judge of the synchronism of rocks so difficult as are those of North and South Devon.

Chudleigh lies in an interesting district, and the walk is very beautiful over the Haldon Hills, with their greensand capping and chalk débris of flints and quartzites. The Chudleigh rock of Middle Devonian limestone rises on the flanks of Ugbrook amidst glens, and wild wood, and streams, the combined effect of which is unusually picturesque. North of Ugbrook is a long faulted mass of limestone containing Devonian fossils, and in the park, which is bounded by the limestone of Chudleigh, Carboniferous sandstones are quarried, while at Weddon Barton the Devonian limestone is overlaid by Carboniferous slates with the typical Posidonomyæ. We also learn, on the authority of Mr. Godwin Austen, that on sinking a well on the line of the Chud brook, horizontal carbonaceous slates and sandstones were found to be resting on faulted and highly inclined Devonian slates. From what we see in this district and about Kingsteignton near Newton Bushel, where there are igneous rocks associated with and altering the Middle Devonians, it appears that the Chudleigh limestones were upheaved before the Carboniferous rocks were deposited. The geologist should go from Chudleigh to Bovey Tracey, and westward, to see the way in which the Carboniferous rocks are broken through by spurs of Dartmoor granite. Volcanic rocks abound in this district, and traverse alike Devonian and Culm measures, as for instance at Botter Rock.

Bovey Tracey is near Chudleigh, and lies at the north-eastern extremity of Dartmoor, and although its celebrated Lignite does not come within a treatise on Devonian rocks and strata, it has too important a geological history to be passed by without allusion. The Bovey Heathfield, as the valley is called, is about six miles long, and its greatest breadth is four miles from Chudleigh Bridge to Blackpool. Situated in the midst of a rugged country, with hills of granite, trap and Devonian limestone rising on every side, it looks exactly what it is, viz. a silted-up lake. Excavations in the deposits of this old lake

basin have shown that they consist of strata of gravel and coarse drift unconformably resting upon stratified layers of silt, lignite, or fossil wood, clay and sand, and we are indebted to the researches of Mr. Pengelly, and M. Oswald Heer, for information as to the age and character of these strata.* Close to the village is a Pottery in which the upper clay, which consists principally of decomposed granite, is used while the baking of the pottery is carried on by means of the Bovey coal or Lignite.

I visited Bovey Tracey twice in 1868, and with the assistance of Mr. Phillips, then manager of the potteries, thoroughly examined the long underground lignite galleries, and saw the "seed bed" and portions of trees in situ.

The sections, with the aid of Mr. Pengelly's descriptions, may be briefly given as below.

1. Pengelly's "Head" (or glacial clay and gravel).	Peat. Sand. White Clay.—Arctic plants. Sandy Clay, &c. Sub-angular stones.
Resting on	
Old Lacustrine.	Clay, black with vegetable remains. Lignite.—Miocene plants.
2. Bovey Lignite.	Sand. Clay. Lignite, and so on to the depth of 66 feet.

First as regards the lower or Lignite formation. It has the appearance of a collection of driftwood in a peaty formation, and looks as if it were of comparatively modern date, for Coniferous trees are sometimes found in it nearly entire, and there are cones, seeds, ferns, and sections of trees showing the rings of annual growth. Altogether more than 40 species of plants have been determined from these lignite beds, but the extraordinary part of the history is that they belong to that vastly remote period of the Planet's history, viz., the Miocene,

* See "The Lignite Formation of Bovey Tracey," Pengelly and Heer, Phil. Trans., Part 2, 1862.

or Middle Tertiary epoch; and a conception of the changes that have occurred not only in Devonshire, but throughout all Northern Europe since those times, may be gathered from a brief résumé of the evidence afforded by the fossil vegetation of that Miocene Period. We all know what Greenland is now! The geologist is aware that in Miocene times there were wide spreading lands, islands, and low lying continents covered with a luxuriant vegetation of forest trees, flowering shrubs and plants, where now Arctic America, Greenland, and Spitzbergen lie covered with nearly eternal snow. These Miocene fossil plants and trees are of the utmost importance, as they convey to us intelligence respecting the climate of different latitudes, during times and periods long passed away, when the temperature of the northern hemisphere was very different from what it is now. Nor is it only of climate that they afford us valuable information; the fossil Miocene flora, and the contemporaneous fauna, present us with valuable evidence respecting the ancestry of our living animals and plants, which since that epoch have been distributed over the face of the earth. Without having seen the animal relics found in lacustrine strata of these Middle Tertiary periods and preserved in the collections at the Jardin des Plantes in Paris, and other foreign museums, no one can have the slightest idea of the great number of quadrupeds allied to, but all differing from, the carnivores, herbivores, ruminants, and marsupials of existing times.

But the Fossil flora, of which in Switzerland alone 800 species of flower-bearing plants have been determined, tells us more than do the animals, of the climatal adaptations of the northern hemisphere in those days. These fossil plants are met with in Devonshire, the Isle of Wight and Hampshire, in Scotland, Ireland, Switzerland, Germany, Iceland, Greenland, and Spitzbergen where they form beds of lignite or brown coal. The total number of plants registered from all these localities is upwards of 3000, and out of these 330 species were evergreens. One great peculiarity which strikes the botanist is that this Miocene flora, which in those times was European, is

now more or less distributed over the whole globe. In the lignites of this age deposited at Bovey Tracey are numerous remains of Wellingtonias (Sequoias) which now are limited to California ; fig trees, vines, laurels, dryandras, and custard apples, many of which indicate a much warmer climate than that which at present exists in Devonshire. On the continent are found numbers of magnolias, tulip trees, evergreen oaks, robinias, figs, cinnamons and camphor trees, the analogues of which grow some in America, some in Japan, and others in Africa and Australia. The Swiss lignites of this age have yielded over 1,300 species of fossil insects, many now peculiar to sub-tropical regions, some of the butterflies being Indian. The fossil Miocene flora of Iceland, and Greenland, have furnished between four and five hundred species of true flower-bearing plants ; and amongst them we find numerous forest trees, analogues of those that now live in our temperate climates. Among them are birch, willow, juniper, rose, oak, plane trees and walnuts. These plants evidently grew on or near the spot where they have been found, for in many instances the petals, stamens and even the pollen of the flowers have been preserved. It is interesting to know that four species of the Miocene plants of Greenland are found in our Devonshire lignites at Bovey Tracey ; they include the Sequoia Couttsiæ, a noble fir closely allied to Wellingtonia, while the difference of latitude between Devonshire and Greenland in those times is also registered by the far more sub-tropical aspect of such plants as the prickly palm (Palmacites Dæmonorops) and tree ferns which flourished on the banks of the ancient Miocene Lake of Dartmoor, but did not grow so far north as the latitude of Iceland and Spitzbergen. Yet there is the fact that magnificent forests grew in high northern latitudes where, since the Glacial period came on, nothing can thrive save the Arctic willow and birch.

When at Bovey Tracey we saw, at the residence of Mrs. Croker, a small collection of the plants of the Lignite, made by the late Dr. Croker. The Miocene plants disintegrate sadly on exposure to the air. Among them were the seeds of water-

lilies, evidence of the fresh water conditions of the old lake, the fronds of Pecopteris, a large tree fern, and sections of the tree stems of the great fir, Sequoia Couttsiæ, so called in honour of the lady who supplied the funds for Mr. Pengelly's explorations and publications, the Baroness Burdett-Coutts. We saw also what particularly interested us, viz., an erratic pebble covered with a soft white clay, on which was an impression of a leaf; and on this clay, and willow leaf, hangs another history almost as strange as that the slopes of Dartmoor were once clothed with a luxuriant sub-tropical vegetation. I believe that the pebble, clay, and leaf impression, came from "the Head," which, with its gravels, flints and white clay, overlies unconformably the Bovey Tracey lignite and associated beds. Mr. Pengelly watched the digging of a section in "the Head," on the Heathfield, measured it off, and observed its unconformability. He also found a considerable number of dicotyledonous leaves lying in the white clay nine feet below the surface of the heath, and below them some roots of trees. The plants from this white clay exhibited a totally different history to that of the subtropical vegetation of the underlying lignite. Mr. Pengelly obtained four species of plants from the "Head," three of willows, which now inhabit cold northern parts, and one species of birch, viz., the dwarf Arctic birch, Betula nana, which has no British habitat south of Scotland, and which we consider rather a prize when found among the deer forests of Sutherland or Ross. I particularly examined the position of the "Head" and its drifts and clays in several localities, and I believe that it is a glacial till, derived from the denudation of Dartmoor in glacial times, and which was washed into the Bovey Tracey hollow, above the lignite of the old silted up Miocene lake. It is certainly a strange fact that the leaves and roots of Arctic and sub-Arctic plants should lie in such close proximity to those of tree ferns, figs, vines, cinnamons, and custard apples, and it is not uninteresting to note that Mr. Divett's pottery should be fabricated of glacial clays, and baked with the brown coal that underlies it, and which is ormed out of the wreck of a rich Miocene vegetation.

Newton Bushell lies at the southern extremity of the old Miocene lake of Bovey Tracey, and the Devonian quarries of Bradley and the surrounding neighbourhood are well worth visiting. These Devonian limestones are underlaid and overlaid by slates and shillets, as at Combe Martin or Ilfracombe. We found, *in situ*, Favosites cervicornis, at Bradley, a coral common to both these North Devon localities, and from these quarries Mr. Vicary obtained many of his best specimens of trilobites, spirifers, orthoceratites, Murchisonias, and the beautiful corals with which his cabinets are enriched. On a hill above Newton, known as "The Decoy," there is an admirable section of chalk drifts with flints capping the hill and dipping at an angle of 20°. There is also an interesting section east of the Devonian limestone of Ogwell, where a patch of undenuded Carbonaceous grits and slates occupies a hollow in the Devonian rocks. These Culm measures are unconformable to the underlying Devonians, and at their base is a conglomerate made up of angular fragments of limestone. This singular little outlier was discovered by Mr. Godwin Austen. The Chudleigh, Newton Bushell, Ogwell, Plymouth, and Torquay limestones are, I believe, considered to constitute an upper range of limestones, corresponding to those of Combe Martin, while the limestones of Ashburton and St. Germans form a lower group equivalent to the lower limestones of North Devon near Ilfracombe.

The celebrated watering place Torquay is too well known to need description. The rocks of the entire peninsula of Torquay are Devonian limestones, with interbedded slates and red grits, interstratified with volcanic greenstones and traversed by quartz veins. Austin's Cove, Babbicombe and Watcombe, should be visited by the geologist; Babbicombe affording a remarkable section, at Petit Tor, of arched slates and limestones. About three quarters of a mile from Torquay, to the right of the Babbicombe road, is the celebrated Kent's Cavern, where bone implements, flint implements, and flint flakes, with other human relics, have been found in considerable abundance, associated with the remains of the extinct mammalia, including

the Cave Lion, Cave Bear, Hyæna, Machairodus, Mammoth, Rhinoceros, Megaceros, Norway Hare, Lemming, and two kinds of Deer. The discovery of these remains was commenced as early as the year 1825 by Dr. McEnery, who rendered Kent's Cavern famous through his researches. In 1840, Mr. Godwin Austen, who, as an amateur, has done such excellent work for the geology of Devonshire, read a paper descriptive of the cavern, and declaring his belief in the contemporaneity of man with the extinct Mammalia. Since that time the discoveries made by the Committee appointed by the British Association, with Mr. Pengelly and Mr. Vivian as the superintendents of the excavations, are too well known to require comment here.

The raised beaches near Torquay are entitled to attention. They have been observed at several places along the coast; but the one at Hope's Nose is the most remarkable. The waters of Tor Bay roll over the site of a submerged forest which extends seaward for a considerable distance. The remains of the Mammoth, with those of the Bos longifrons, have been found between Torquay and Torbay in forest peats. It is very doubtful, however, whether the Mammoth remains are not derived from some more ancient deposits. There is no good evidence that this animal lived up to the period of the submerged forests. I have before observed that these submerged forests occur in many places along the coasts of Wales and Devonshire. They were observed long ago; that of St. Bride's Bay, near St. David's, was noticed by Giraldus Cambrensis 700 years ago; that of Mount's Bay in Cornwall, is recorded by Leland more than 300 years since; and that of Whitesand Bay, near the Land's End, is mentioned in 1758 by Dr. Borlase, the great Cornish antiquary, whose private notes I have seen, and who states that trees and large horns of deer were excavated at Sennen Cove from a peaty deposit now covered by the sands.

There is an upthrow, already alluded to, of Lower Devonian rocks extending from Upton near Brixham, to Livermead and Meadfoot; in these Torquay beds Whitesand Bay* fossils have been found, and among them Pleurodictyum problematicum

* This Whitesand Bay is near *Looe*.

and Bellerophon bisulcatus. The Middle Devonians, however, appear east of Brixham. When quarrying for limestone in 1868 at Brixham, not far from the railway station, the workmen laid open a fissure from which more than 500 jaws of hyænas were extracted. We saw some teeth and bones still fixed in the breccia on the side of the fissure. One perfect canine of a hyæna adhered to the cliff, and my friend Mr. Lyell picked up a perfect pre-molar as it was lying in the débris below. We felt inclined to fill our pockets with the bones and relics of the extinct mammalia, but the owner of the quarry had particularly requested that no one would touch these fossil treasures. This bone fissure was nearly opposite the celebrated Brixham cavern which lies across the Brixham harbour, and which tells the history of the antiquity of cave men and cave animals even more distinctly than does Kent's Cavern. Crossing to the other side of Brixham, and taking a look at the stone where William of Orange landed, we see Windmill Hill rising to a height of 180 feet above tide water. Windmill Hill Cavern is situated on the western side of the hill. It is about 80 feet above the bottom of the existing valleys and 100 feet above the tide-way, and it has four external entrances, three on the western, and one on the northern slope of the hill. The bottom of the valley consists of blue clay, which is full of stumps of trees and vegetable remains, and is a portion of the submerged forest which underlies the Bay of Torbay, and contains remains of red deer, horse, and wild boar. It was not until I had examined the physical history of the Brixham cavern under the guidance of Mr. Pengelly that I realised the great physical and geological changes which that portion of England has undergone since the cave men and cave animals left the relics of their existence in the caverns of Windmill Hill. The cave deposits contained many flint implements worked by man, associated with numerous bones of the extinct mammalia. It is evident that in this cavern, unlike many of the hyæna dens, the bones were deposited by running water, as every bone lay with its longest axis to the place of deposit, and with the bones and flint tools were many well rounded frag-

ments of quartz, trap rocks, and brown hematite of iron, none of which could have come from Windmill Hill, which consists entirely of Devonian limestone; neither could they have been derived from any of the limestone valleys by which the cavern is now bounded.

Indeed it is quite evident that since the remains of men and cave animals were carried into the cavern by such a stream as flows at the bottom of the present valley, a series of changes in the district must have happened as follows:—

1st. The valley was eroded to a depth of at least 100 feet since the deposition of the cave relics.
2nd. After its excavation was completed, it was partially refilled by a deposition of blue clay.
3rd. On this clay grew the trees of the submerged forest period, and the forest animals lived.
4th. Since the forest period, the entire country was lowered to the extent of at least 40 feet.

The geologist should examine the rocks along the coast between Windmill Hill and Berry Head, where fissures in the Devonian limestone may be seen at low water, as well as along the cliffs, filled with infiltrations of New Red Sandstone which once overlaid the whole of this district, and which has been denuded over the principal part of the Brixham area. Near Crocker's Cove these infiltrations may be observed with cross fissures of carbonate of lime. Outliers and small patches of the New Red Sandstone lie here and there, unconformably, on the Devonian limestones; and large boulders may be seen along the cliffs, lying on the planed off and eroded surface of the limestones.

Berry Head is a fine escarpment of limestone, and near the ruined camp on the summit was a fissure containing remains of hyæna and bones of other extinct mammalia. I have already alluded to the walk from hence to Mudstone Bay to see the faulted Lower Devonians rising through the Torbay limestones of Berry Head on the east and Sharkham Point on the west, and the walk to Dartmouth should be taken if only to see the relics of the New Red Sandstone formation resting above the Devonian slates and limestones of the cliffs. From Dartmouth, it would be well to visit the metamorphic

rocks of the Salcombe district. They consist of mica slate, quartz rock, and chlorite schists which, on the coast, form a grand series of cliffs. The slates of Slapton sands, between Dartmouth and Start Point, are Middle Devonian and of a green colour, like those of Aveton Giffard, and to the north of Kingsbridge; I am not aware that they have yielded any fossils.

Near Huckham, Laurentian looking rocks set in, and from them to Start Point, chlorite rocks dip inland and northward, as indeed do the Slapton argillaceous slates. It is my impression that the Start and Bolt Head strata are Laurentian or Cambrian rock masses which have been upheaved from below through the Lower Devonian rocks, and which have served as a counteracting force to the earth movements that upheaved the granite of Dartmoor. At Holt's Cove are Cambrian looking slates with veins of quartz. Kingsbridge would be a good starting point when proceeding to visit Bolt Head. This cliff rises 430 feet from its base and consists of mica slate very like the Holyhead rocks of North Wales. These rocks are unconformable to the Middle Devonian strata which come on near Marlborough Church, and by Bolt Tail. I believe that they run east and west in a hidden anticlinal under the sea, and are the cause of the inward dips of the coast strata from their seaward axis. In going from Bolt Head to Bolt Tail, over Bolbury Down, the geologist must beware of some treacherous gullies and chasms which have been caused by a landslip seaward. They are absolutely dangerous and require caution. The landslip of Bolbury Down is a singular scene; indeed the coast is most interesting notwithstanding that the rocks are unfossiliferous.

PLYMOUTH LIMESTONE.

In the south of England, Plymouth and its neighbourhood stands unrivalled for the numerous and instructive objects it offers alike to the geologist and the antiquarian. There is nothing in all England equal in scenery of its kind to Plymouth Hoe, the Sound and its ships, and the view from the Park at Mount Edgecombe.

The Plymouth limestone commences at the west, at Impacombe, south of Devonport, and it is overlaid by the red grits and slates of Mount Edgecombe Park. Slaty rocks resembling those of Ilfracombe, and like them imbedded with volcanic ashes, appear from below the Plymouth limestone on the North. It appears that a long synclinal trough extends from Tor Bay on the east to Plymouth Sound on the west. The beds contained in this trough are believed to represent the upper and lower Ilfracombe slates of North Devon. Sections of the slaty beds on the Torbay side occur at Totness and Harburton where they may be compared with the faulted Lower Devonians of Cornworthy, and near Plymouth the upper slates may be seen south of Plymstock; and in the railway sections west of Plymouth the lower slates underlie the Plymouth limestone. The argillaceous slates which overlie the Mount Edgecombe limestone, correspond to those of Jenny Cliff Bay, where they may be seen on the coast, while at Cawsand Bay there is an intrusive Trap rock at the Barracks. This trap is a reddish felstone and it sends veins into the Devonian rocks which are continued to Penlee Point and Rame Head. The Preston quarries lie a little east of Plymouth, and are fine excavations in the limestones. They may be easily reached by the little steamers which continually run up and down the Catwater from the Barbican. The Preston quarries supplied all the limestone employed in building the breakwater of the Sound, and the extent of ground over which the limestone has been quarried must be seen to be understood. During the excavations for these works numbers of bones, teeth, and jaws of the extinct Mammalia, among them those of hyæna, mammoth, rhinoceros, Irish elk and deer were discovered by the workmen. I saw a collection of these remains in the possession of Mr. Hodge of Preston. The most remarkable specimen in his collection was a well preserved tusk of hippopotamus which he obtained from a cave which was discovered in quarrying limestone below Plymouth Hoe, on the other side of the water. According to Mr. Hodge's account, the remains of many of the extinct Mammalia in this

district were washed into fissures, while others falling in were cemented to the sides by carbonate of lime, the cracks afterwards becoming filled with loam and angular fragments, thus forming a breccia. There was no cave or hyæna's den exposed in the Preston quarries. Following the Catwater up to Laira Bridge a junction of the limestone and the lower slates may be seen well displayed. South-east of Oreston are the limestones of Plymstock and the volcanic rocks and limestones of Yealmpton, all of which should be examined. Above the river Yealm, at Yealm Bridge, is a cavern which from all I could learn was sealed with a mass of *old river drifts*, and must have been a hyæna's den like that on the Wye near Ross. In it were discovered numerous bones of hyænas with their coprolitic matter; mammoth teeth and bones; with teeth and bones of rhinoceri, horse, and bos. The walk back may be taken by the leaning spire of Ermington Church* (said to have been struck aside by lightning), over some lower Devonian strata which are brought up between Yealmpton and Burratton, and which are a prolongation westward of the Mudstone Bay and Cornworthy slaty rocks. The volcanic rocks here exposed may be the igneous representatives of the forces which upheaved these Lower Devonians.

SOUTH CORNWALL.

I found it impossible to ascertain the relative position of the Devonian rocks in the extreme south of Cornwall. At Michael's Mount we find slate and granite, and "elvans" with greenstone resting on the slate. At Penzance are slates traversed by greenstone, and felstones which occur again at Newlyn, but what those slates are it is difficult to determine. The Geological Surveyors have marked them Devonian on their maps. I examined the coasts between Mount's Bay and the Lizard, and between St. Ives Bay and St. Agnes Head, but did not succeed in finding the vestige of a fossil in the slate rocks along either shore. There are numerous interbedded traps, or elvans, everywhere associated with the slates, and the

* The railway at Ivy Bridge may be reached in three miles from Ermington.

north coast between Godevrey Lighthouse and Samphire Island, which is nearly opposite Tehidy, presents a good example of the weathering of cliffs by the action of the sea. Opposite Samphire Island are the remains of an old camp, which I visited with Mr. William Borlase of Castle Horneck, and we agreed that it must have been half destroyed by the falling of the cliff since man established his defences on the brows of the precipice. Now, scarcely half of the outer portion is left, the waves having undermined and brought down the seaward side. Northward of St. Agnes Head, at Watergate Bay, Middle Devonian fossils are found in abundance, and at Perminzen Bay, Dinas Cove and Pengueen in the Padstow district they occur in great numbers. Among them are Stringocephalus, Pentamerus brevirostris, Atrypa desquamata, and Spirifer hysterica, a North Devon form, found at the Valley of Rocks near Lynton.

Mr. Pengelly has discovered plates of Pteraspis (or Scaphaspis) at Bedruthen Steps, and this combined with the Lynton spirifer looks as if the Lower Devonians were brought up at Padstow. I am not acquainted with the Tintagel district, but am informed by Sir William Guise, and Dr. Holl, that the Middle Devonian slates are there much traversed by volcanic rocks, and they contain numerous fossils, especially in the neighbourhood of Trevenna, Spirifer disjuncta being the most characteristic species.

The Upper Devonians of Braunton and Baggy Point in North Devon, do not appear to be represented anywhere in South Devon and Cornwall, for neither the Pickwell rocks nor the highest Devonians of Braunton occur on the south of the Culm measures, which in the south are unconformable to the Devonians proper.

Everywhere in the south we see evidence of the great volcanic action and pouring forth of igneous matter during the deposition of the Devonian rocks, which were upheaved and distorted to a certain extent before the Carbonaceous series were deposited, although the earthquake movements of Dartmoor and Camelford were continued in Post-Carboniferous

times. Dr. Holl, who has given much attention to the subject, believes that in the south the Culm measures have been laid down on the denuded surface of the older rocks. The fossiliferous rocks of South Petherwin were generally held to be Upper Devonian—and are placed by Mr. Salter on the horizon of the red slates of Morte Bay, but Dr. Holl gives reason for believing them to be Middle Devonians.

GRANITES OF DARTMOOR, BROWN WILLY, AND CORNWALL.

The Dartmoor Granite has been described by Sir H. de la Beche, Sir R. Murchison, Prof. Sedgwick, Mr. Godwin Austen and others. There are several localities in which its relation to the Culm measures and Devonian rocks may be studied.

Near Bovey Tracey, as already mentioned, and between that place and Skerrington the Dartmoor granite throws off the Culm measures to the S.E. Indeed the geologist who will stay a day or two at the pretty village of Moreton Hampstead,* and will examine the ground between that place and Dunsford, will see for himself the impossibility of doubting the igneous character of certain masses of granite, whereas, in other localities, the granite appears to have become consolidated before its upheaval through the stratified rocks. On the south side of Dartmoor the granite may be seen throwing off the Devonian rocks near Ivybridge, and any one staying at Plymouth and taking the route to Tavistock may see numerous sections showing the stratified rocks dipping away from the granite. Around Tavistock also are some important igneous rocks.

The Brown Willy granite throws off the rocks southwards, and they dip towards Liskeard, and on the north it has carried up the strata northwards of Hingston Down. In short the beds dip away all round it.

The Penzance and Land's End granites throw off the beds

* A railway runs to Moreton Hampstead from Newton Bushell through Bovey Tracey.

that flank their edges wherever they are exposed, and in some instances penetrate the slates with veins. This is the case W. of Mousehole and E. of Gurnard's Head on the N. coast of the Land's End peninsula. Nevertheless the masses of intrusive trap in this country are very puzzling, and it is often impossible to unravel the jumble of slate and granite, elvan and greenstone that everywhere occur. On several occasions when exploring the granite districts of Penzance I was accompanied by Mr. William Borlase. He was good enough to show me many of the most celebrated antiquities of the country and the rude stone monuments of a pre-historic race.

On the banks of the rocky Tavy, and on the west flank of Dartmoor, are the ruins of the Saxon abbey of St. Rumon founded by Ordgar, Ealdorman of Devon. He was the father of Elfrida Queen of King Edgar, and it was to his castle that Edgar sent his favourite courtier Athelwold, to see the beautiful Devonian lady who ended by murdering first her own husband Athelwold, and then King Edgar's eldest son. The "Bedford" at Tavistock stands on a part of the site of this Saxon abbey, they say on the site of the Chapter House.

Brent Tor is a volcanic rock rising to the height of more than 1100 feet, and is within a pleasant walk of Tavistock. It was supposed by Sir H. de la Beche to have been a centre of volcanic action, and there is little doubt that this was the case. The rocks forming the Tor are composed of volcanic cinders and ashes, their vesicles being filled with carbonate of lime and cemented into a conglomerate. The term Brent is as old as the time of Ordgar and Elfrida, and is derived from the Saxon "brennan," to burn, not in allusion to its volcanic ashes, but originating in the beacon fires which no doubt often blazed upon its summit. The little church on the top of the hill stands on lava, and the vesicular structure of the rocks looks as if the igneous masses were sub-aerial, and had not been accumulated under water. These volcanic rocks and those of Milton Abbot are generally understood to be of Carboniferous

age and to have been contemporary with the volcanic ash beds, grits, and chert which characterise the Culm or Carbonaceous system of Devonshire. It is probable too that we behold here the heralds of those volcanic and earthquake movements which in post-Carboniferous times brought up the Dartmoor granite and with it the overlying Devonian rocks and Culm measures, throwing off these beds in some localities into nearly vertical positions.

ORGANIC REMAINS.

The organic remains of the Devonian rocks, or of the Marine Devonians, are now ascertained to comprise Fish which are common to the Old Red Sandstone and which are of that peculiar palæontological type found in the Upper Silurians, the Passage Beds, and the Lower Old Red. Among the typical shells of the Lower Devonians are Orthis arcuata and Chonetes Hardrensis with Alveolites suborbicularis, a coral common in the Lower Devonians of the Rhine. These Lower Devonians of England are believed by Mr. Etheridge to be the equivalents of the Spirifer sandstone of Coblentz.

The Middle Devonians of England are full of Corals, with many shells and trilobites. The fish remains are scanty, and undeterminable, although they occur in the Ilfracombe beds. Fifty-one species of corals are enumerated by Mr. Etheridge, none of which pass into the overlying Carboniferous rocks. Favosites cervicornis is a typical Devonshire coral. Stringocephalus, Megalodon, and Uncites are genera of shells peculiar to the Middle Devonians both in England and the Eifel Limestone of the continent. In the Eifel Limestone in Germany the Old Red fish Coccosteus has been found associated with the Stringocephalus. Pteropods occur; and Orthoceras and Cyrtoceras are Devonian forms of Cephalopoda.

The Upper Devonians are rich in Mollusca, and more than 150 species are enumerated by Mr. Etheridge, of which a fifth pass upwards into the Culm measures or Carboniferous deposits. Spirifer disjuncta, Lingula Molei, Curtonotus, Avicula Damno-

niensis, Cucullæa Hardingii, with the Trilobite Phacops latifrons, may be said to be typical forms characterising the Upper Devonians. With these are Spirifer Verneuilii, Rhynchonella pleurodon and casts of plants such Knorria and Bornia. Clymenias also are found, and these Cephalopods are so abundant in Germany as to give to the Upper Devonian strata on the continent the name of Clymenian Schiefer.

CHAPTER IX.

LOWER CARBONIFEROUS ROCKS (MOUNTAIN LIMESTONE).

Age of Carboniferous Deposits—Mountain Limestone of North Wales—Tregarnedd—Owen Tudor—Puffin Island—Historical Records of—Great Ormes Head—Geological Changes of the—Rare Plants on—Caves of Cefn—Vale of Clwyd—Eglwyseg Rocks—Outliers—Clee Hills—Former Continuity of Mountain Limestone—Pen-Cerrig Calch—Castell Cerrig Cennen—Cardiff Castle—Llandaff Cathedral—Ewenny Priory—Section of Southerndown Cliff—Peninsula of Gower—Caves and their Remains—Swansea Castle—Tenby—St. Govan's Head and Eligng Stacks—Sea Birds of—Caldy Island—Bone Caves of—Pembroke Castle—Chepstow—Sections near—Valleys—Excavation of—Tintern Abbey—Wye—Ancient Course of—Caves of the Doward Hills—King Arthur's Cave—Evidences of the Antiquity of Man—Organic Remains of the Carboniferous Limestone.

THE ROCKS OF THE DOWARDS, ON THE WYE,

In which are situated the Hyena's Den of Arthur's Cave.

			ORGANIC REMAINS.
Carboniferous (Mountain) Limestone.	Limestone.	*Corals.*	Lithostrotion basaltiforme, Lonsdaleia floriformis, Amplexus, Cyathophyllum, Clisiophyllum, Syringopora, Michelinia.
		Bryozoa.	Fenestrella, Hemitrypa, Polypora.
		Crinoidea.	Pentremites, Actinocrinus, Platycrinus.
Limestone Shale.	Dark and grey shales passing into yellow sandstones below.	*Mollusca.*	*Brachiopoda.* — Productus giganteus, P. hemisphæricus, P. semireticulatus, P. scabriculus, Spirifera striata, S. rotundata, S. trigonalis, S. glabra, Terebratula hastata, Aviculopecten sublobatus, Pleurotomaria carinata.
			Cephalopoda. — Orthoceras laterale, Goniatites crenistra.
		Crustacea.	Griffithides longiceps, Phillipsia.
		Fish.	Cladodus, Psammodus, Cochliodus, Oracanthus, Ctenocanthus, Onchus, Megalichthys Hibberti.

THE term Carboniferous is applied to those Palæozoic strata which overlie the Old Red Sandstone, and which are the repository of the chief supplies of that all important mineral, Coal.

Coal, nevertheless, is not confined to these Palæozoic strata, as the term Carboniferous somewhat implies. The coal-field of the State of Virginia, in the United States, is of the age of the Upper Trias, and according to Sir Charles Lyell, who visited the Blackheath mines in Chesterfield county, these Mesozoic coal seams rival or even surpass those of the Palæozoic coal-fields. The coal strata of Brora, in Sutherlandshire, belong to the Oolitic period; while coal of Tertiary age is worked in

some localities in Germany and Switzerland. Neither can the plants which constitute the Palæozoic coal be considered primeval, for, although few traces of land plants have been discovered in Great Britain and Europe, either in the Silurian or Old Red strata, in America Dr. Dawson has determined nearly one hundred species of fossil plants from rocks of the Old Red Sandstone epoch. Some of these belong to Coniferous trees, while some fragments of fossil wood exhibit the structure of Exogens.

It is well to remember that in European areas the Silurian and Old Red fossils hitherto obtained are records only of the sea beds of those long epochs. We know nothing as yet of the plants and animals of their islands or continents, and the fact of the detection of a highly organised exogenous tree in strata, in America, intermediate between the Silurian and Carboniferous periods, is a warning against the supposition that all land vegetation antecedent to the Carboniferous epoch was necessarily low in organisation and structure.

MOUNTAIN (CARBONIFEROUS) LIMESTONE.

The Mountain limestone is beloved by the Geologist for its picturesque scenery, its caves with their stores of old bones, and the number and variety of its fossils; by the Botanist for the rare and beautiful plants nourished in its fissures and on its slopes; by the Archæologist for its cromlechs, old camps and ancient dykes; and by the Historian for its memories of many a hard battle, and many a struggle for independence fought out to the death among its ravines and dingles.

The Mountain limestone of North Wales is divided by local geologists into three groups or divisions. The lowest consists of a series of strata of pale coloured rocks, interbedded with layers of red clay, and marked by the occurrence of the Productus hemisphericus. P. cora and P. semireticulata are the characteristic Brachiopoda of the lower beds, and the smaller corals, as Syringopora, Favosites, and Chætetes, are the prevailing forms of Zoophytes. The Producti are a family of well

defined Brachiopoda, which are not found in the Silurian rocks. These lower limestone beds are used for fluxing. The upper and middle beds show a difference both in the mineralogical character of the rocks and in the fossils which they contain. Large corals are abundant, and the large Productus, P. giganteus, associated with P. quicuncialis, P. longispinus, and other smaller Producti, takes the place of P. hemisphericus and P. Martini.

In North Wales the Mountain limestone is well exposed in the Isle of Anglesea, between Red Wharf Bay and Dulas Bay, and in passing from east to west the geologist may commence with a cliff section of Cambrian rocks to the east of Red Wharf Bay, and examine Mountain Limestone and Old Red Sandstone flanked on the west, at Dulas, by Llandeilo beds traversed by volcanic rocks. Traeth Coch, or Red Wharf Bay, is famous for its rare shells. The hill of "Bwrdd Arthur," or Arthur's Round Table, which rises on the east, is a mass of Carboniferous rock. The view from its summit (on which are the remains of a large camp) is very fine, and is described by Mr. Pennant as "an intermixture of rock, sea, and alps, most savagely great." The Moelfre limestone stretches southward, by Llangefni to Maeldraeth Bay, where, though slightly developed, it is surrounded by the Millstone grit and Coal measures of Maeldraeth. The physical geologist will observe particularly the isolated masses of Carboniferous limestone as occurring in Anglesea, in the Moelfre and Llangefni district, on the south-east across the river Braint, where we may call it the limestone of Llanidan, at the Menai Bridge, and at Llanvihangel and Puffin Island. These are all fragments of strata, no doubt once continuous with the limestone of the Ormes Head and the Carboniferous rocks of Denbighshire.

Again the great downthrow on the north-west, between Berw-uchaf and the sea, causes the Permian and Coal Measure rocks to abut on Cambrian strata, and it is this great boundary downthrow which Prof. Ramsay believes has preserved the Coal measures of Maeldraeth from the effects of old denudation. It was against the Mountain limestone rock of Moelfre Bay,

westward of Red Wharf Bay, that the "Royal Charter" struck in October 1859. Four hundred and sixty-five persons lost their lives through this fearful shipwreck. Upwards of two hundred corpses, which were recovered from the waves, rest in the little graveyards of Llanallgo and Penrhos Llugwy; others the sea never restored.

Near the little town of Llangefni, in the pleasant vale of Cefni, is Tregarnedd, the once famous residence of a distinguished Welsh chieftain, Ednyfed Vychan, who lived during the fourteenth century, and was the minister of Llewellyn the Great. Rowlands tells us that he took up arms against the English in 1322, and suffering a defeat by the English troops, he retreated to his house at Tregarnedd, which he had strongly fortified with a foss and ramparts. He was afterwards taken prisoner and executed at Rhyddlan Castle. From Ednyfed Vychan descended Owen Tudor, the husband of Catherine of France, widow of Henry V., the progenitor of a race of kings, and, according to Halle, a man "garniyed with many goodlye giftes both of nature and of grace," "brought furth and come of the noble lynage and ancient lyne of Cadwallader, the last kynge of the Britonnes." He was born at Penmynydd, near the Llanfair station. We know not if Queen Catherine was ever there, but she was buried at Westminster by the side of Henry V.; while Owen Tudor, who was beheaded at Hereford, after the battle of Mortimer's Cross, was there buried, according to Leland, in the church of the White Friars, long since a ruin. Tregarnedd is now only a farm house; it owes its appellation to the Carnedd, or heap of boulders, which stands near, arranged in position by the "old people," a long time ago.

Rowlands, the antiquary and author of the "Mona Antiqua Restorata," was vicar of Llanidan. He died in 1723 and was buried in the old church, famous for the miraculous stone of Giraldus Cambrensis called the "Maen Morddwydd" which was built into one of the walls. It resembled a human thigh, and whatever distance it was carried, returned of its own accord the following night. "Hugh, Earl of Chester, in the reign of King Henry I., having by force occupied this island

and the adjacent country, heard of the miraculous power of this stone, and for the purpose of trial ordered it to be fastened with strong iron chains to one of a larger size and to be thrown into the sea; on the following morning, however, according to custom, it was found in its original position, on which account the Earl issued a public edict, that no one from that time should presume to move the stone from its place."* The old church has been demolished and a new one has been erected at Bryn Siencyn. The district between Llanidan and the river Braint is described by Rowlands in his "Mona Antiqua," as crowded with cromlechs and other antique remains, many of which, like the boulder stones of St. David's, have no doubt been broken up for roads and buildings. Several, however, still remain, as at Bodowyr and Perthi-Duon.

The Carboniferous limestone extends along both shores of the Menai Straits. On the Caernarvonshire side these rocks are faulted against Cambrian strata, and at the base of the cliffs on both sides of the Menai Bridge, are beds of Old Red Marl with conglomerates which dip under the limestone of Plas Newydd. There are also red beds with conglomerates which *overlie* the Carboniferous limestone of the south of Anglesea opposite Caernarvon, and which I believe are remnants of the Permian series discovered in Denbighshire by Mr. Maw. A Trap dyke, 134 feet wide, and consisting of a compound of felspar and augite, was described by Prof. Henslow, near Plas Newydd in Anglesea. It indurates Carboniferous shales and converts them into a hard jasper. The shale contains fossil shells, such as Producti, which in contact with the trap are nearly obliterated. The limestone also is changed by the dyke and crystallised.

The Outliers of Llanvihangel and Priestholm, or Puffin Island, on the north-east corner of Anglesea are remarkable both for their geology and their historic lore. The island appears to have been a place of retirement for religious recluses, and in the sixth century a saint of that period, Seiriol, established a cell there called *Ynys Seiriol*, while Giraldus tells us that it

* Hoare's Giraldus, vol. ii., p. 103.

was called Priest's Island, "because many bodies of saints are deposited there and no woman is suffered to enter it." Mr. Bloxam, the well-known authority on ecclesiastical architecture, told me lately that he has discovered at Priestholm remains of Anglo-Saxon architecture. After this once revered spot was deserted by man it became the colony and building place of swarms of sea-birds, and Bingley describes the island as "literally covered with puffins" which were allowed to be eaten in Lent, instead of fish, and were sold at one shilling per dozen for pickling. On this north-eastern spur of Anglesea stands Penmon (Head of Mona). The Priory is said to have been founded by Maelgwyn Gwynedd, King of Wales, the head of the family of the Gwynnes, during the sixth century, and a school was established there by the saint Seiriol above alluded to. The ruins of the refectory are all that now remain of Penmon Priory. The fragment of denuded limestone of which Puffin Island is composed is of great interest to the geologist as, after studying this district, he cannot for one moment doubt that it was formerly a connecting link between the Great Ormes Head, eastward over the sea, and the Llanvihangel mass close by.

The Mountain limestone masses of the Great and Little Ormes Head are worthy of especial study. There can be little doubt that, until within a late geological period, the Great Orme was separated from the Little Orme by a narrow strait. There is a legend that the whole area of sand and sea from Llandudno to Puffin Island was dry land within the human epoch, and taking into consideration the evidences we possess of the extreme antiquity of the human race in Great Britain, it is very probable that such may have been the case. From a survey of the Great Orme with the eroded sea bottom on its summit, its raised sea cliffs and other phenomena, it is evident that the whole hill was submerged during that period when the boreal marine shells of Moel Trifaen and Aber were deposited together with glacial boulders on a sea bottom now elevated nearly 1500 feet above the sea. With respect to the narrow strait which intervened between

Diganwy and the Mountain limestone of the Great Orme I believe that firstly, after the upheaval of the Great Orme, and on the emergence of the land after the glacial submergence, it was filled with boulder clay, which very probably formed flat low lands during a long period; secondly, that after the denudation of the boulder clay, the sea washed for a time through the Llandudno straits; and thirdly that the sea has silted up these straits with the recent sands and drifts that overlie the boulder clay which is exposed near the baths at Llandudno and in which Mr. Darbyshire found glacial shells.

The strata at the Ormes Head have been worked for copper for centuries past. The Ty Gwyn mine is become unproductive owing to the sea water covering the works, after 93,000*l.* worth of ore had been obtained. In the course of their labours in this mine the workmen broke into an old work, where they found the tools of some ancient miners, stone hammers, and bone augers. The bone instruments were impregnated with copper. Mountain limestone fossils may be found on the top of the hill north-west of the copper mine. In the Museum of Practical Geology in Jermyn Street, there is a specimen from this locality of one of the last of the trilobites, Griffithides longiceps, and also the Productus longispinus.* Both these are Carboniferous limestone fossils.

The platform of rock beyond the telegraph, and marked in the Guide Book as Hwylfargaino, is remarkable, as it is neither more nor less than an elevated sea bottom with pot holes, water worn ridges, and boulders. When there with Sir C. Lyell, I obtained a pebble from a deep pot hole filled with clay. This pebble was of a hard trap rock, and I have little doubt that it was washed into the pot hole when the summit of the Ormes Head lay beneath the waters of the glacial seas, and thus, like the glaciated slabs we find protected by a roche moutonnée, or a great mass of moraine matter, it tells no uncertain tale of a bygone history of the rocks of Llandudno.

The Great Orme and its neighbouring hills of Mountain

* Catalogue of Fossils by Huxley and Etheridge.

limestone are favourite localities for the botanist, and the fact that limestone rocks and a calcareous soil especially promote the vegetation of certain plants, while trap rocks are favourable to the growth of other kinds, is well exemplified around Conway and Llandudno, as in a walk of only five or six miles the botanist passes from a comparative desert as regards beautiful wild flowers, to a garden of Nature's own growing. The Silurian rocks between Conway and the Ormes Head are barren of wild plants of any interest, and the outlier of Millstone grit which overlies the limestone S.E. of the Little Orme is still more destitute of botanical treasures, but when in the summer months we pass from these strata on to the Mountain limestone itself the beautiful blossoms of the Geranium sanguineum, and Helianthemum, tell us almost as surely as would the occurrence of a Productus, or a Griffithides, what are the strata we are treading under foot. If by chance a stray specimen is met with out of bounds (which happens but rarely) it looks stunted and unhealthy. The Great Orme is celebrated as being the only locality in Britain where the Cotoneaster vulgaris, a Pyrenean plant, is known. It has now become so rare, through the rapacity of collectors, that the few struggling plants that are left are confined to one limestone ledge. When searching for the Cotoneaster, some years ago, we failed to find it, notwithstanding the assistance of kind and active friends, until by good fortune we happened to meet with Mr. Inchbald, the author of the Botany of Llandudno,* who generously supplied us with a specimen, and on a rocky ledge covered with hazel, spindle tree, holly and privet, pointed out the Cotoneaster with an earnest supplication that we would not eradicate and utterly exterminate it. Other plants which flourish on the limestone of the Ormes Head are the Wild Madder (Rubia), Silene nutans, and Hippocrepis (Horseshoe Vetch) a common plant on chalky downs. On the trap rocks of Dyganwy grow the Maiden Pink (Dianthus deltoides) and Lathyrus sylvestris (Everlasting pea), Chenopodium (Good King Henry) and the Digitalis purpurea (Fox-glove), which

* See Mr. Williams's Guide Book.

particularly favours volcanic rocks. I gathered on the shore near the Little Orme the beautiful Mertensia maritima (Sea Gromwell) a plant both rare and local. It belongs to the Boraginaceæ, but it has fleshy glaucous leaves.

From the Ormes Head the Mountain limestone of North Wales trends eastward towards Colwyn and Abergele, and by St. Asaph, Denbigh and Ruthin. In the vale of Clwyd it flanks the Silurian hills, known as the Clwydian range, on both sides the vale. Northwards it is developed from Llanasa, by Holywell, and west of Mold to Llandegla, and ranges south by the fine escarpment known as the Eglwyseg Rocks, three miles east of Llangollen, then makes a detour three miles west of the town of Oswestry, and rises on its most southward prolongation into a bold headland north of the village of Llanymynech. Between this point, save the Clee Hills in Shropshire, the Mountain limestone is nowhere to be seen until we reach the little isolated outlier of Pen Cerrig Calch high up on the summit of the Black Mountains in Monmouthshire. But these isolated outliers are just the points that teach volumes to the physical geologist with respect to the former continuity of strata, as I have endeavoured already to impress on my readers.

The Mountain limestone is developed in the neighbourhood of Abergele. We have already alluded to this little town as being surrounded with many points of interest. Within reach is the wild tract of hills composed of the Denbighshire grits, scarped and rugged, and a country cut up into valleys, first by the action of the glacial sea and since by atmospheric denudation; while the geologist should especially mark the way in which the streams, here and there, cut right through the escarpment of Mountain limestone that bounds the Wenlock shales and flow into the Clywd. Traces of a submerged forest have also been seen at low water on the shore at Abergele, furnishing proof that here, as at Borth, near Abersytwyth, Tenby, and many other places on the Welsh coast, low flat lands extended which are now covered by the sea. Mr. Pennant, who wrote a description of a tour in Wales in

1770, notices a traditionary account that the sea in old times had overwhelmed a large tract of inhabited country which had once stretched for two miles northward of Abergele, and he quotes a Welsh epitaph to the effect that "In this churchyard lies a man who lived three miles to the north of it." This may be a tradition but there is no doubt of the fact of the existence of trunks of trees being imbedded in what is now the bottom of the sea. The wood is not fossilised but has been used as fuel after being well exposed and dried. West of Abergele, at Lysfaen and Colwyn, the lower limestone beds put on a dolomitic structure.

The Caves of Cefn, six miles from St. Asaph, are situated in an escarpment of Carboniferous limestone which ranges above a lovely ravine through which the river Elwy flows. The cave phenomena at Cefn are somewhat peculiar. First, with respect to the formation of the caves in the Mountain limestone. There is little doubt that they owe their origin to the action of water on old fissures and cracks which were originally formed by the dislocating movements to which the whole country has been subjected. Secondly, the Cefn caves appear to have once constituted part of an ancient coast line, for on their sides and roofs are wave marks, pot holes, and swallow holes, and out of one of the very highest pot holes I and Sir C. Lyell obtained a quantity of marl and detritus which, when forwarded to Mr. Gwyn Jeffreys for examination, proved to contain fragments* of *marine shells* and *corallines*. It appears also that considerable upheaval and dislocation of the Mountain limestone has occurred since the deposition of the mud with marine remains in the pot hole, for the dip of the beds has been altered, and the old sea caves with their wave and water marks now dip into the hill and not, as formerly, towards the valley. Thirdly, the cave earth, which once nearly filled the caves was so full of animal remains that it was carted away for manure, a few only of the relics of bears, hyænas and hippopotami being preserved by Dr. Falconer, and Mrs. Williams Wynn, the owner of the caves. Dr. Falconer

* These fragments are now in the Worcester Museum.

also found sea shells below the remains of the cave animals. Lastly, a long lapse of time has evidently passed away since the Marine period of the caves, for not only are they situated at a considerable height above the river, but at the base of the cliffs there is a striking example of an old river bed with unmistakable river shingle at a level above the highest floods of the existing river Elwy. From a cave in the Cefn district, my friend, Mr. McKenny Hughes, last year obtained the remains of The Glutton (Gulo Luscus), an animal now confined to Northern Europe.

From St. Asaph there is an interesting excursion up the vale of Clwyd to Denbigh and Ruthin. The physical structure of the vale is that of a great synclinal curve the eastern boundary of which is formed by the Wenlock rocks of the Moel Fammau range, and the western by the hills which stretch from Conway, and run east of Llanrwst to Derwen. Thus the rocks which are newer than the Upper Silurians, including Old Red, Carboniferous, Permian and New Red strata, *lie in a trough.* The Upper Old Red may be seen between the Wenlock shale, which forms the base of the trough, and the Carboniferous limestone a little south of Denbigh; and again west of Llanfwrog, near Ruthin, where also a patch of Caradoc slates with fossils, is faulted through the Wenlock shales. It appears that the Carboniferous limestone which now underlies the vale of Clwyd was deposited in an ancient synclinal curve which was formed and denuded before the Carboniferous period, while it is certain that the Coal measures were eroded by still later denudations and before the deposition of those Permian rocks which occur on the eastern side of the vale of Clwyd, and which intervene between the Lower New Red Sandstone and the Mountain limestone. The section where these rocks are exhibited *in situ,* extends near Llanfair Chapel, on the road between Pentre Glyn and Caer Owen, to a point on the road to Llandegla where the Carboniferous limestone dips away from the Upper Silurian boundary.* The New Red Sandstone occupies the bottom of the

* See Geological Magazine, Aug. 1865.

vale of the Clwyd and it appears from the position of these rocks in certain localities, as between Denbigh and Llanrhaiadr, that hollows had been excavated in the Carboniferous limestone before the deposition of the New Red strata; indeed, everywhere throughout this part of Wales we see proofs of the denudation which took place before the commencement of the Carboniferous limestone epoch and of the still greater denudation which succeeded its deposition.

The Mountain limestone is well developed at the Eglwyseg cliffs near Llangollen. Here we have in ascending order the lower light coloured beds, the characteristic fossils being the Productus hemisphericus, and typical coral the Syringopora ramulosa. The middle strata, which consist of dark grey rocks, furnish Spirifera and the bivalve Sanguinolites; while in the uppermost beds are specimens, occasionally of large size, of Productus giganteus. We learn from Mr. D. C. Davies that these uppermost beds of grey fossiliferous limestone have in some localities "dirt beds a yard or more in thickness." The Eglwyseg rocks which constitute a fine escarpment, derive their name from the Pillar of Eliseg. It is believed that Eliseg lived at Dinas Bran about A.D. 600, and that the pillar was erected by his grandson Concenn. It was originally twelve feet high and is inscribed all round with letters, and we are told that it was supposed to have been broken down in about the time of the civil wars and was re-erected by Mr. Lloyd of Trevor. When this took place Mr. Davies does not say; but he records that the tumulus was opened before the restoration of the pillar, and "the remains of a full sized man were found reposing on a large slab, guarded with flat blue stones and covered with the same, the whole forming a stone box or coffin. The bones were entire and the skull and teeth, which were very white and perfect, were particularly sound. They were supposed to be the remains of Eliseg."

The rambler on the banks of the Ceiriog should not fail to visit Chirk Castle, which stands on the site of the ancient fortress of Castell Crogen, near which the bloody battle was fought between Henry II. and the Welsh in 1165. Mr.

Pennant says that the place is still called "Adwyr Beddau," or "the pass of the graves of the men who were slain there." Portions of the present building date from the time of Edward I. but a great deal of it was destroyed during the civil wars. Leland describes its appearance as follows:— "There is on a smaul hille a mighty large and strong castel with divers towers, of late welle repayred by Sir William Standeley the yerle of Darby's brother." The rare Noli-me-tangere (yellow balsam) grows hard by, and near the junction of the Ceiriog and the Dee flourishes the noble Inula Helenium (Elecampane), a true British sunflower, which grows also on Mountain limestone in Gower. The Moonwort (Botrychium Lunaria) grows near Chirk Castle which is on the Coal measures; and Lycopodium clavatum with L. Alpinum are found on Dinas Bran and the Eglwyseg rocks.

The Mountain limestone and Lower Carboniferous rocks are more fully developed in North Wales, and the upper Coal bearing series of shales and sandstones are thicker towards the south as in the great basin of Caermarthen, Glamorgan, and Monmouth and still farther south in the county of Pembroke.

In the Coalfields of Dudley and Wolverhampton, east of the Silurian region, the Mountain limestone and the limestone shale are wanting altogether. The coalfield of Wyre Forest is deposited on Old Red Sandstone, and we find the Carboniferous limestone setting in towards the north and south-west. Professor Jukes believes that "a narrow rocky island or chain of islands, stretched east and west across the centre of what is now England, during the early part of the Carboniferous period, so that while the Carboniferous limestone was being formed in the seas to the north and south, it thinned and died out as it approached the ridge of dry land."

At the Clee Hills, the Carboniferous limestone only appears in two small patches, one on the north and the other on the south of the Titterstone Clee. These thin beds of limestone form the basement of the Titterstone Clee coalfield, and are exposed north-eastward of the hill at Oreton and Farlow. The Upper Old Red Sandstone of Farlow has already been

alluded to, and the junction of the Yellow Sandstone and Mountain limestone may be seen in a quarry south of the road on walking southwards over the Farlow ridge. There are large quarries at Oreton which have afforded many fish teeth and spines to the researches of Mr. Weaver Jones of Cleobury Mortimer and Mr. Baugh of Bewdley.* Fine specimens of the palatal teeth of Orodus ramosus are the gems of Mr. Jones's collection, with a new form of tooth named deltodus, and there are also the teeth of helodas, cochliodus, cladodus, and psammodus. These Mountain limestone fishes are believed to have been forms allied to the existing Cestracion or Port Jackson shark now living in the seas of China and Australia. The palatal teeth of cestracion fishes are adapted for crushing shell fish and crustaceans as in a mill. The backs of these fish are also armed with strong spines, many fine fossil specimens of which, belonging once no doubt to the owners of the teeth, were found at Oreton.

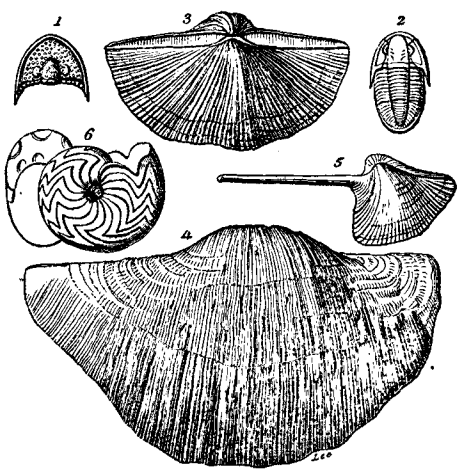
The Fossil Shells lead us to suppose that the limestone was a deep water deposit, on account of the abundance of Brachiopoda and the absence of the Lamellibranchiate bivalves which inhabit shallower water. Spiriferæ and Rhynconella are the species most frequently met with, as is the case in the lower strata of Carboniferous shale and limestone of Dean Forest and the South Wales coalfield. Rhynconella pleurodon abounds at the bottom of the series, and Conularia also occurs. Of Gasteropoda, Professor Morris determined Euomphalus pentangulatus.

The southern mass of the Clee Hill limestone occurs between Cornbrook and Knowl. On the eastern side it is nearly vertical, and the sections here afford a clue to the physical history of the neighbourhood. There is little doubt that great dislocation of the Mountain limestone of the Clee Hill district occurred before the deposition of the Upper Carboniferous rocks. The earthquake forces underneath this tract were active before the Coal beds were laid down, and before

* Professor Morris and the late Mr. G. E. Roberts published a list of fossils collected by these gentlemen. Quart. Journ. Geol. Soc., May, 1862, p. 99.

the masses of lava which now fill the fissures had been injected and poured out over the surface of the coalfield. It appears also that considerable denudation was going on during the same period; and the effect of strong currents probably extended eastward, and swept clear the Carboniferous areas of Dudley and Wolverhampton during the Mountain limestone

SOME FOSSILS OF THE CARBONIFEROUS LIMESTONE.

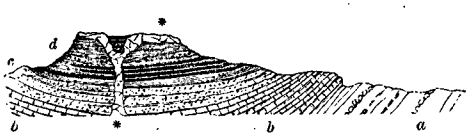


1, Brachymetopus Ouralicus, de Vern. 2, Phillipsia pustulata, Schloth. (Ph. gemmulifera, Phill.). 3, Spirifer striatus (?), Martin. 4, Productus giganteus, Sow. 5, Pleurorhynchus aliformis, Sow. 6, Goniatites crenistria, Phillips.

period. Both at Oreton and at Knowlbury there is proof of great dislocation of the limestone anterior to the deposition of the Millstone grit, and this is a fact of some importance for physical geologists. Nothing in physical geology appears to me to have less foundation than the supposition that such outliers as the Clee Hill limestone and those of North Wales were *little isolated coral reefs*. The Millstone grit which overlies them should be sufficient to overthrow such theories, for, even allowing that isolated coral reefs may have accu-

mulated in the Lower Carboniferous seas, we cannot suppose that the Millstone grit could have been deposited above every outlier, by accommodating and peculiar currents which spread their particular and peculiar pebbles over those accommodating coral islands, and adapted their flow to such widely distant and separated areas as are those of the Little Orme district near Llandudno, the Titterstone Clee, and Pen Cerrig Calch near Crickhowell. Fossil shells and fish spines (Ctenacanthus) similar to those found at Oreton occur at Knowlbury. Producti have been obtained at Gorstly Rough; thus the fossils yielded by these patches of limestone are identical with those found in Carboniferous limestone districts miles and miles away, on the flanks of Dean Forest, in the South Wales coalfield, or on the isolated outlier of Pencerrig Calch.

SECTION ACROSS THE CORNBROOK COAL-BASIN OF THE CLEE HILLS.



a, Upper beds of Old Red or Devonian. *b*, Carboniferous Shale and Limestone. *c*, Millstone-grit. *d*, Coal-measures. * Erupted Basalt, which has risen through and overflowed the Coal.

There is a fine example on the Titterstone Clee Hill of a volcanic rock penetrating among and overflowing three divisions of the Carboniferous series. The local name for this trap is "Jewstone" or "Dhustone," and in one or two places, as at the "Giant's Chair," it puts on a columnar structure. The coal is baked and altered in contact with the Dhustone and is worked by means of shafts and galleries which are driven underneath the platform of the igneous and basaltic rock which caps the hill. The brown Clee Hill has but a thin covering of igneous rock on its summit.

The physical geologist, having concluded the examination of the Clee Hills and having seen the *downthrow* of the Carboniferous limestone and the Upper Yellow Sandstones on the

east at Farlow and Oreton, should cross the hill to Ludlow, take the train for Abergavenny and then proceed to Crickhowell and prepare to investigate Pen Cerrig Calch the next day, as outliers so distant as the Mountain limestone of the Clee Hills and Pen Cerrig Calch, should be visited in succession as soon as possible while yet fresh in the memory. I have more than once compassed this expedition and visited the Clee Hills one day and Pen Cerrig Calch the next.

The walk from Abergavenny along the banks of the Usk to Crickhowell is very instructive, and close to the former place, near the bridge, is a fine section of Old River drifts. These drifts occur at intervals all along the river side, while high up on the flanks of the hills, even to a height of a thousand feet above the river, are masses of *Boulder drift*, the accumulations of vast quantities of glacial detritus which nearly filled the valley before it had been scooped out by river action. These terraces of gravel and detritus tell their own tale and attest the work of denudation in past times.

And now for Pen Cerrig Calch! This insulated outlier of Lower Limestone shale and Carboniferous limestone capped by Millstone grit and attaining a height of 2200 feet above the sea, is about five miles distant from the edge of the northern rim of the South Welsh coalfield and is separated from the mass of that great coalfield by the denudation of the intervening valley of the Usk, the valley itself running along a line of fault which has upheaved the Old Red hills of the Black Mountains, with Pen Cerrig Calch on their summit, on the north bank of the river, and depressed the strata on the south. The distance of the Mountain limestone of Pen Cerrig Calch from the northern mass of Llanymynech south of Oswestry, cannot be less than sixty miles as the crow flies, while it must be nearly forty miles from Oreton and the Clee Hills on the north-east, and about twenty miles from the Carboniferous rock of Dean Forest. When examining Pen Cerrig Calch the best way is to trace up the series of rocks from the Lower Old Red Cornstones of the vale to the Millstone grit where it rests on the summit of the Blorenge on

the right bank of the Usk, and then to cross the valley and take up the section on the left bank of the river by the Upper Old Red of the Daren, to the overlying Carboniferous limestone and Millstone grit of Pen Cerrig Calch. And he who does this and remembers the record of the corresponding strata across the valley and beholds the Usk now flowing in its deep broad vale, will assuredly not return without having strongly marked upon his mind the impressive truths here revealed of former dislocations of the earth's crust, of the long continued denudation of past ages, and other records taught him by the physical history of that noble isolated Limestone Peak. Sir R. Murchison investigated the remarkable geological position and features of this outlier, when engaged upon his "Silurian System," the name Pen Cerrig Calch, the top of the limestone crag, being inserted upon the Ordnance map, led him to ascend the Black Mountains in order that he might "ascertain why such a name had been used in a district appearing to consist exclusively of Old Red Sandstone."

Between Merthyr Tydvil and Brecon are two outliers of Mountain Limestone which are cut off from the rim of the South Welsh coalfield and surrounded by Old Red Sandstone. They lie to the east of the road between Merthyr and Brecon, among the beautiful glen scenery of Aberscriban and Cwm Cellan.

Another most interesting Mountain Limestone outlier is an insulated rock on the little river Cennen, three miles and a half S.E. of the town of Llandeilo, and on which stands the picturesque ruin "Castell Cerrig Cennen." This singular fortress is situated in a small valley on a precipitous outlier, and downthrow, of Mountain Limestone which rises to a height of 300 feet above the Cennen and is faulted between hills of Old Red Sandstone. It is a most remarkable place, both as regards the position of the old Castle, the physical geology of the district and the striking and peculiar scenery.

I invite attention to a few of the leading features of these

Mountain Limestone outliers. First: Those who visit the districts of Pen Cerrig Calch, near Crickhowel; Cefn Sil Samus, between Merthyr Tydvil and the Brecon Beacons; and Cerrig Cennen, near Llandeilo, cannot fail to observe that the Mountain Limestone once covered a considerable area north of the South Wales coalfield where now it is entirely denuded. This is a plain and self-evident fact. Secondly: The isolated outlier of Pen Cerrig Calch *is elevated* with the uppermost strata of the Old Red of the Daren; while on the other hand the Mountain Limestone of Cerrig Cennen with its underlying Upper Old Red, is thrown down to an extraordinary extent, as may be seen at once by any visitor to the spot who will consider that the elevated summits of the neighbouring mountains, the Caermarthen Vans, are composed of the same beds as those on which the limestone rock of Cerrig Cennen is supported. In short, instead of occupying its present position in the valley, the *proper place* for the Cerrig Cennen is *on the summit* of the Caermarthen Van-sir-gaer which is 2300 feet above the sea, consequently the Van-sir-gaer is elevated and the Cerrig Cennen thrown down, a dislocated mass of rock dropped as it were against the Lower Old Red and Upper Silurians of the southern prolongation of Trichrug. This downthrow is very instructive and is an admirable lesson to those geologists who are inclined to dispute the dislocations and contortions of strata. The faults around this district are particularly worthy of observation, and, as Professor Harkness remarked, "let you know what a fault is." There are two transverse faults running from north to south, in one of which is situated Castell Cerrig Cennen. Producti and other fossils of the Carboniferous limestone occur here, and the strata are fissured. The so-called "Well" is a natural fissure pierced by loopholes. There are also caves in the limestone. The Old Red Conglomerate is seen in the lane near Cerrig Cennen House and the Upper Yellow beds appear on the rising ground N.W. of the Castle. But little is known respecting the history of the Castle. The site has however long been a

haunt of human beings, for we learn from Rees that a stone hatchet resembling a chisel was dug up here, as well as some Roman coins of the time of Domitian; also that there is a manuscript in the British Museum* which ascribes its erection to Urien, Lord of Is Cennen, who was supposed to have been a knight of King Arthur. The architecture of the existing ruins does not, I imagine, lead us to ascribe greater antiquity to them than the days of Edward I.

No other outliers of Mountain Limestone occur along the northern rim of the South Wales coalfield with the exception of a patch at the mouth of Taff river, near Llanstephan, and another isolated mass south of Llaugharne, and Llansadurnen on the right bank of the Taff, both of which are without doubt remnants of an area of Carboniferous limestone which formerly connected that of the northern edge of the Pembrokeshire coalfield at Gilman Point and Pendine, with the opposite limestone between Kidwelly and Llan Ishmael at the western extension of the South Wales coalfield.

The Carboniferous limestone of the South Welsh Coalfield forms a girdle to the coalfield and everywhere dips under the Upper Carboniferous strata. The most instructive points for the geologist to visit are places on the northern and north-western escarpments, as showing the succession of strata between the Carboniferous and Silurian series of rocks, and also at the eastern extremity of the Coalfield in the neighbourhood of Pontypool in the vales of the Ebbw and Rhymney, where the same regular order and succession of strata may be studied between the upthrow of Silurian rocks at Usk and the Carboniferous limestone which supports the Coal measures.

On the western escarpment the section which occurs between Llandeilo and Llandybie is interesting with its contorted Coal measures and the neighbouring Mountain Limestone of Cerrig Cennen Castle and Fair Carn Isaf, and on the southern escarpment of the Coalfield these strata may be studied on the Taff Vale Railway, a few miles from Cardiff. Here the

* Harl. MSS. 2300.

points of interest which may be seen in a walk of ten miles are numerous.

Cardiff, the old metropolis of the county of Glamorgan, owes its name to its position on the Taff, the word being derived from Caer-Taff, the fortress on the Taff where it is believed that the Roman general Aulus Didius erected a fort. In 1089 Caradoc of Llancarvan relates an inroad of Rhys ap Tuwdwr into Glamorganshire and the building of a "strong castle" by Jestyn ap Gwrgan. In the natural course of events Rhys was killed and Jestyn also, and the Norman, Robert Fitzhamon, established himself at Cardiff and reigned in their stead. The ruins of the memorable fortress, which Giraldus calls "the noble castle of Caerdyf," can never be surveyed by the historian and antiquarian without a shudder at the recollection of the monstrous cruelty inflicted within its walls upon Duke Robert of Normandy by one who called himself a Christian king. Taken prisoner after the siege of Tenchebray, the eldest son of the Conqueror was shut up for life in Cardiff castle by Henry I., surnamed Beauclerk; who not content with usurping his brother's English crown, next essayed to rob him of his Norman dukedom and succeeded in his attempt. It was not to be supposed that Robert would neglect any opportunity of regaining his liberty, and upon hearing of a fruitless endeavour to make his escape, we read that the king not only prescribed "a greater restraint and harder durance" but commanded that the eyes of his unfortunate captive should be put out. "And a basin of copper or iron made red hot was held close over the victim's eyes till the organs of sight were seared and destroyed." An apartment in the gate house is said to have been the duke's prison for twenty-six years.

We learn that Henry II. passed the night at the Castle on the first Sunday in Easter after his return from Ireland, and received sundry predictions as he left the chapel of St. Piranus from "a man of a fair complexion with a round tonsure and meagre countenance," as to what would happen to him if he did not command a strict keeping of Sunday throughout his

dominions. This "chepelle of St. Perine," where Henry offered up his devotions, was, we are informed by Leland, in Shoemaker Street. Leland has been very particular in his account of the town as it appeared in his days. He says it "is well waullid and is by estimation a mile in cumpace, in the waullie be five gates." The castelle "is a great thing and strong, but now in sum ruine." "The dungeon town is large and fair." Speaking of the convent of Grey Friars he says: "In the year 1404, Owen Glendwr burnt the southern parts of Wales and besieged the town and Castle of Caerdyf. He took the town and burnt it all except one street in which the friers minors dwelled, which together with their convent he left standing for the love he bore them." In the time of Charles I. the troops of Cromwell are said to have entered the castle by a subterranean passage which was betrayed by one of the royalists.

Within two miles of Cardiff, on the right shore of the Taff, stands the old city of Llandaff with its venerable Cathedral, ancient cross, and its once fortified Bishop's palace. We gather from Sir R. Colt Hoare that the original foundation of this church has been attributed to a British King, Lucius, and dates as early as the year 180. Its first bishop was Dubritius, who, on being promoted to the archbishopric of Caerleon, was succeeded by St. Teilo. In the year 1107 Urban was appointed bishop and he "pulled down the ruinous old church which was only twenty eight feet in length and thirty feet in height. Most interesting also is the geology around Cardiff, with the magnificent section of Rhætic and Lower Lias beds, as displayed in the headland of Penarth. This section should be examined with care, in order to compare it with the remarkable series of Lower Lias and Rhætic strata which are developed near Southerndown, and Dunraven, on the Channel, and rest on the Mountain Limestone. The change in the mineral condition of the Rhætic strata should be observed.

A short run of seven miles on the Taff Valley railway, will land the geologist at Pentyrch where boldly rises the Great

Garth; and Castell Coch, or the Red Castle, overhangs the pass on an escarpment of Mountain Limestone. Tradition says that it was through this pass that Owen Glyndwr descended to attack Llandaff and Cardiff. From hence an interesting walk may be taken across country to the magnificent ruins of Caerphilly Castle, which stands some three miles to the north-east, upon the Coal measures, and faces a ridge of Mountain Limestone hills on the south. It is worth visiting for the sake of its extensive ruins and also on account of the change of scenery involved in the position of a fortress situated on the Coal measures as compared with Castell Coch, on the Carboniferous limestone. Mr Daines Barrington, maintains that Caerphilly was built by Edward I. Camden says that it is of such vast and stupendous antiquity that it is almost universally allowed to be a Roman work. Probably both are right, for from the style of its architecture there is little doubt that much of the structure now standing was built in Edward I.'s time, and was erected on the ruins of a Roman city, as indicated by Caer a term suggestive of Roman occupation. There are few historical accounts respecting this castle. It stood a siege during the reign of Edward II., when it was held by Hugh le Despencer for the king, who, however, was obliged to fly to the priory of Neath. Leland describes it as "sette emonge marisches." Again, the erection of a redoubt, with the evident application of gunpowder to effect the overthrow of the stronghold, tell a history of destruction which may probably be referred to the time of Charles I. and the presence of the Parliamentarians. There is a notice in Gough's "Camden" that tumuli, or barrows, containing urns with burnt bones, were opened on Gelligaer, a hill to the north of Caerphilly.

Westward of Cardiff and Llandaff, near Cowbridge and Bridgend, are masses of Mountain Limestone, which are worthy of examination on account of their physical position with respect to the Triassic and Rhætic series, and that of the Lower Lias. It will be understood by the Geologist that the Carboniferous limestone of this district is but a portion

of a great extent of this rock, which once swept over the area now occupied by Swansea Bay, and was formerly conterminous with the limestone on the opposite coast of Gower.

The run by railway from Cardiff to Bridgend is about twenty miles, and in a walk from Bridgend by Ewenny Priory, Ogmore Castle, and Southerndown to Dunraven Castle, the naturalist passes over some most interesting geology and by some very venerable edifices. Near Bridgend are some sections which should be examined before starting to investigate the geology of the coast. On the Ogmore river, about two miles to the north of the town, the Middle Keuper Sandstone of Worcestershire and Warwickshire is quarried, and is overlaid by Upper Keuper marls; while a section of Rhætic strata, with the Bone bed of Aust, may be seen at Cwrt-y-Coleman, on the South Wales railway, about a mile and a half west of Bridgend. Close to the station is a fine section of Lower Lias, with numerous gryphites and other characteristic fossils; and these beds pass upwards, on the north-east, into strata containing some of the fossils of the Middle Lias or Marlstone. At Ewenny, two miles south of Bridgend, the rising ground above the river is capped with a mass of till containing drifted and angular blocks.

Every lover of antiquity should visit Ewenny Priory, a relic of Norman times, which still remains much as it was in the days of Giraldus Cambrensis. He says, in his "Itinerary," "The Archbishop having celebrated mass early in the morning before the high altar of the Cathedral (Llandaff), we pursued our journey by the little cell of Ewenith to the noble Cistercian monastery of Margan." Sir Richard Colt Hoare, the annotator of the "Itinerary," informs us that both Leland and Tanner ascribe the foundation of this religious house to Sir John de Londres, Lord of Ogmore Castle, but that "an ancient tombstone which lies neglected in the floor of the chancel, fixes for a certainty the foundation of this church on Moris de Londres," who, it appears, founded the church of St. Michael de Ewenny in 1141. The simple groined roof of the

choir, and the neglected tombstone of its founder bearing this inscription, in old characters, claim particular attention:—

ICI GIST MORICE DE LUNDRES LE FVNDUR
DEU LI RENDE SUN LABUR. AM.

"In the southern transept is an ancient altar-tomb, supporting the mutilated effigy of a knight in armour." "The same happy gleam of sunshine, a pail of water and a broom, enabled me to ascertain the true original of this effigy, which was intended probably to commemorate a friend or follower of Moris de Londres."

SIRE ROGER DE REMI. GIST ISCI
DEU DE SON ALME EIT MERCI. AM.

Having visited this Priory more than once, we can heartily sympathise with the feeling of this distinguished antiquary (Sir R. Colt Hoare) when he says, "The satisfaction with which I viewed this building, as having remained untouched, unaltered since the days of Giraldus, and, I might add also, from the period of its foundation, was considerably damped upon beholding its present ruinous and dilapidated condition."

Ogmore Castle is situated in a Scotch-like vale at the junction of the Ewenny and Ogmore rivers. But little of it is now left save the Norman keep; and it must always have been a small fortress. It appears from the pedigree of the Lords of Ogmore, given by Powel in his history of Wales, that "William de Londres received in reward of service from Robert Fitz Hamon the castle and manor of Ogmore." Moris de Londres also lived here.

In going from Ewenny Priory to Southerndown we pass through an elevated bare district of Mountain Limestone, and following the river Ogmore, by the side of the limestone downs, to the sea coast, we see a series of strata known as the "Sutton Stone series," resting on the Carboniferous limestone. The basement beds of the Sutton series consist of a remarkable conglomerate of Mountain Limestone fragments set in a white paste, and they are apparently conformable to the Mountain

Limestone upon which they rest. The Carboniferous floor of the ancient sea, upon which the Sutton beds were laid down, exhibits in places, where these strata are eroded, pavements full of beautiful weathered Corals, Encrinites, and Producti. The Sutton strata, which are very like the White Lias of Lyme Regis, are claimed as Rhætic by Mr. Tawney and Mr. Etheridge; but they are, I understand, considered to be the lowest beds of the Lias by Mr. Charles Moore, Dr. Wright, and some other geologists.* We found many fossils in the quarries on the coast below the farmhouses of Sutton, and among them were Ostrea multicostata (a Muschelkalk species) and Pecten Suttoniensis.

Towards Southerndown the Mountain Limestone dips at a considerable angle, while the Sutton series continues nearly horizontal, showing the alteration of dip in the limestone here, before the deposition of the Rhætic and Liassic strata. The Southerndown strata which overlie the Sutton beds have been hitherto regarded as Liassic. They may be seen in Southerndown cliff, and are a very singular series of strata as regards their mineralogical character, and are altogether unlike any Rhætic or Liassic beds I have ever seen elsewhere. At their base is a bed of conglomerate full of chert fragments, at the very bottom of which Sir W. Guise found Ostrea liassica, an acknowledged Lias shell. There is a grand section along the coast, from the hut built for a coastguard shelter below Sutton to the great fault at Dunraven, where the Carboniferous limestone is seen to be tilted, as if by a Trap dyke, and the Sutton and Southerndown series curving over it at a low angle. The colour of this cliff section, with its brown, black, grey, and light-coloured strata of different geologic epochs, studded by the bright green foliage of some plants, and the beautiful blossoms of others, will not easily be forgotten by those who see it under a clear sky and a setting sun. At the summit of the Southerndown cliffs, and at Dunraven above the coast line, the well-known zone of Ammonites Bucklandi, and Gryphæa incurva, of the Lower Lias set in, in their

* See Quart. Journ. Geol. Soc., May, 1866, p. 73.

usual form, and succeed the singular beds with the peculiar fossils already mentioned.*

Dunraven Castle, the Dindryfan of Welsh history, is believed to stand on the site of an ancient structure once frequented by Caractacus and his father, Brân ab Llyr. In the cliffs on the shore there are some caverns worn by the sea, respecting which a rather curious ornithological note is recorded. "In one of these caverns Mr. Williams, the Welsh poet, found several swallows in a torpid state clinging in clusters to each other by their bills."

North-east of Dunraven lies Llantwit Major, or Llan Illtyd Fawr. Every antiquary looks with reverence on the church of St. Illtyd, for it is said to have been the schoo of St. David, St. Teilo, St. Leonorius, St. Magliore, St. Sampson, of the historian Gildas, and of the Welsh bard Taliessin. This information is derived from the Liber Landavensis, an ancient manuscript history of the Bishops of this see.

The Mountain Limestone is developed in the peninsula of Gower across Swansea Bay. It commences at Oystermouth Castle, on the north, and ranges along the southern coast in a succession of fine headlands and retreating bays, to the singular rocks on the western coast known as Worm's Head, which at low tide constitute a rocky promontory, and at high water become two little islands and outliers of Mountain Limestone. The scenery here is more striking than anywhere else in Gower, and the geology is instructive as showing the gradual but certain destruction that ensues from the action of the waves upon the hardest rocks. Leland mentions the "little promontori caullid Worms Heade," and it would be interesting to know how much of the rocky causeway, now covered at high water, has been worn away by the waves since the days of Bluff King Hal. Numerous common fossils are found in the Mountain Limestone quarries. The pleasant village hostel in the centre of the peninsula, known as the "Gower Inn," is nearer to the localities which interest the geologist and naturalist than the Mumbles or Swansea. It is

* See Section, Quart. Jour. Geol. Soc., vol. xxii., May, 1866.

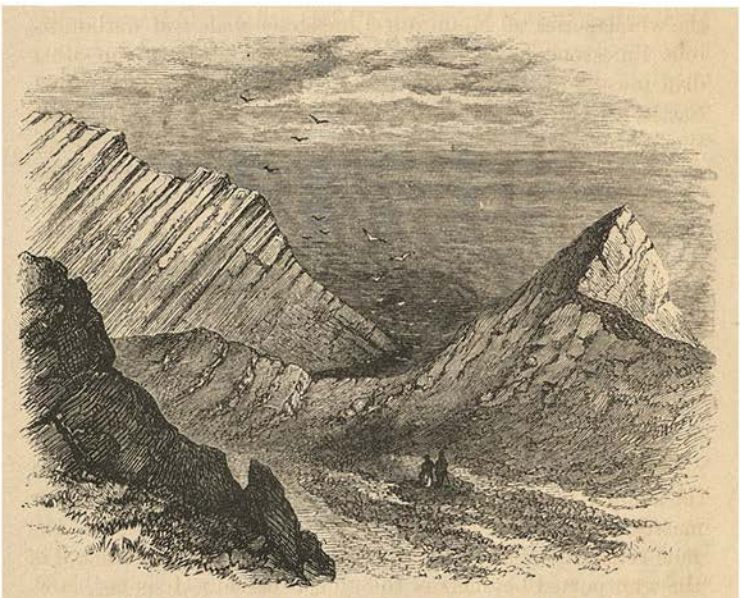
situated in a nook of woodland by a brawling stream, and is within a walk of the most interesting geological localities in Gowerland. "And whether," says Mr. Bevan, "the visitor be geologist, antiquary, botanist, aquavivarian, artist, or simply a pedestrian seeking a pleasant excursion, he will be sure to find something to repay him. Iron bound coast with glorious sea views, picturesque little valleys and inland dells, old churches, still older castles and camps, druidical remains, and those of incomparably more ancient date—the remains of a former world—are the principal features to tempt an excursionist."*

The first point for the geologist to visit from Gower Inn should be the long tract of hilly land running nearly east and west, known as Cefn Bryn. Here the position of the Mountain Limestone with respect to the Upper Old Red, of which the hill is composed should be especially observed, as the limestone is thrown off from the flanks of Cefn Bryn, and has a totally different dip from that which occurs on the sea shore. This tells a tale to the geologist respecting an upheaval of the coast line since Cefn Bryn and the limestones on its flanks were elevated into the high moorlands that form the axis of Gowerland. The Old Red Conglomerate is seen *in situ* on the summit of this hill, and the sides are studded with boulders and masses of *drifted* Millstone grit, which occur also in all the valleys of Gower, and were probably deposited during the drift epoch, when the whole of the peninsula was beneath the glacial seas. The cromlech, known as "Arthur's Stone," is a transported mass of Millstone grit, of which the nearest parent rock *in situ* is near Kidwelly, fifteen or sixteen miles to the northward. A walk southwards leads to the promontory of Pwlldu Head, to the Bone caves, now celebrated through the investigations of Colonel Wood, and Dr. Falconer; and to Pennard Castle where the rare Draba aizoides grows on the time-worn walls, as it also grows on the cliffs between Pennard, and the Worm's Head, these being the only localities where it is found in England. Anemone ranunculoides (the yellow

* A Week's Walk in Gower.

wood anemone) also grows wild in the woods of Stout Hall, and I possess a specimen kindly sent by Mrs. Wood. It is one of our rarest British plants, but is abundant in Norway.

The Caves of the peninsula of Gower have long been celebrated. I had the pleasure of visiting them in 1863, in com-



THE HOME OF DRABA AIZOIDES, GOWER PENINSULA, S. WALES.

W. V. Guise. (Mountain Limestone.)

pany with Sir C. Lyell, Lieut.-Col. E. R. Wood of Stout Hall, and Mr. Starling Benson, and in 1865 I again examined the physical geology of the coast line. The conclusions I arrived at from the investigation of the caves and their physical history, differ somewhat from the opinions held by other geologists on this subject, and may be erroneous. I therefore give a few notes on the phenomena I observed, with respect to the elevation, and alterations of level, of the land and coast, leaving

the geologist to work out his own convictions on the very intricate and difficult problem presented by these cave deposits.

It appears to me that the whole of the Gower peninsula was totally submerged during the glacial submergence period. We see it in the masses of Millstone grit, known as Arthur's Stone, which rest stranded on the Old Red of Cefn Bryn, from which the whole series of Mountain Limestone shale and Carboniferous limestone have been denuded. We see it in the other drift masses which stud the Old Red moorlands above Scurlege Castle, and between Llandewi and Llangenydd, a little north of the Worm's Head. No human hands, or human agency transported those rocks and placed them on the sites they now occupy. They stand now as they stood thousands of years ago, geological witnesses of an epoch long since passed away, an epoch when the waters of a sea traversed by icebergs and ice-rafts, washed above the highest lands of Gower, and these icebergs laden with rocks torn from some point more or less distant, grounded and melted, leaving their freight of transported materials to be upheaved upon the hill-top, or scooped out vale, of the slowly emerging land. And these strange rock fragments in later periods were appreciated by an early people who marked their weird characters and strange positions. Some of the smaller stones they moved into the proximity of the larger masses, and thus we have the cromlechs and stone circles—the rude religious monuments of a rude human race, constructed of the transported boulders of the glacial period. It is not, however, only upon the hill-top that these boulder masses occur in Gower. They may be seen in many localities on the sides of the vale. I detected several large boulders of Old Red Conglomerate standing on the sides of the little valley which leads from the Gower Inn, by Pennard Castle, to Oxwich Bay, and resting against the base of the Mountain Limestone hills. There is also a place above Stout Hall where Lieut.-Col. Wood directed my attention to elevated beds of drift on the flanks of Cefn Bryn. Another point to be observed is the angular character of some of the Boulders proving that they have never been submerged or exposed to the action of waves or currents. This

remark applies to certain boulders in the low valleys as well as to those upon the hills, and may be worthy of the attention of those geologists who imagine that since the glacial period, the land of both North and South Wales has been subjected to a series of movements similar to those of a figure known as "Jack-in-the-Box," and has been continually "emerging" only to be again "submerged." It appears that in Gower, as in other parts of Wales, there are *two kinds of boulders*, one kind rounded and rolled, belonging to the period of the marine stratified drifts, and the transportation of which we may attribute to iceberg and iceraft agency; while the other kind appertains to a *later epoch*, a time when the land was elevated to much the same position that it now occupies, and owes the transportation of its boulders to the agency of land ice and snow as they were moved down the valleys and slopes from parent rock masses now *in situ* in Gowerland.

I have already alluded to the difference of dip in the Mountain Limestone from the Old Red axis of Cefn Bryn, as compared with the dip of the same strata along the line of coast. The geologist will not fail to mark this alteration of dip in the short distance between Cefn Bryn and the coast near Paviland and other localities. There has evidently been elevation of the limestone *along the coast line*, which elevation has not affected the same beds in the interior of the peninsula. Another point, also worthy observation, is that the limestone, and with it the Bone caves, is more elevated towards the west, as at the Worm's Head and Spritsail Tor, than eastward at the Mumbles.

The Raised Beach of Mewslade Bay, near Paviland, was first observed by Mr. Prestwich, who came to the determination that it was of *later date* than the boulder clay on Cefn Bryn; and at Rhossily a modern angular breccia overlies the raised beach. Depressions of level have been inferred to have taken place on this coast in comparatively modern geological times, for it is ascertained that, along the shore, the sea now rolls over the site of an ancient land, with the remains of a submerged forest. The probability is, that this was a low tract occupying a

valley between the coasts of Gower and Devonshire; and which, on the elevation of the land, towards the close of the glacial (submergence) period, was a tract of elevated Boulder clay, then a forest, and since that, the present submerged sea area.

I would now direct attention to certain phenomena regarding the Bone caves themselves. The bottom of the Caves has been filled with marine silt and shingle, while the sides and roofs exhibit marks of the washing of the waves and the usual effects of tidal action on coast caverns. This is the marine period of the caves. When this sea floor was elevated above the reach of the tides, a succession of floors, which may be termed land floors, were formed by the dripping of stalagmite and the intermixture of angular débris of the Mountain Limestone. This breccia contains bones of the extinct cave mammalia, and is itself overlaid by a *modern* "head," or talus, consisting of fragments which are loosened from the rocks by frost and atmospheric agencies, and roll down the sides. The *old* talus of breccia was probably contemporaneous with the habitation of the caves by some of the extinct animals, when the rocks of the coast presented a different slope to the shore than at present. It is cemented with carbonate of lime, and is as hard as the limestone rock itself, and shows by its dip that it was upheaved with the caves and the coast. The talus of angular breccia at Devil's Hole (or Bowen's Parlour) and at Bacon Hole, which appears to be an ancient cliff talus, cemented by carbonate of lime, is well worthy of remark.

The contents of the different Bone caves were chiefly examined by Lieut.-Col. E. R. Wood, and a description of them was given by Dr. Falconer.* The principal caves are Spritsail Tor, on the west coast, the Paviland caves, Raven's Cliff, Long Hole, Bosco's Den, Minchin Hole, and Bacon Hole, all on the south coast. Spritsail Tor Cave, when explored by Colonel Wood, was proved to have been a hyæna's den. Sealed hermetically underneath the stalagmitic bone breccia were found many gnawed bones of the ox, horse and stag, associated with the bones, teeth and coprolites of the hyæna. Besides these,

* Quart. Journ. Geol. Soc., November, 1860, &c.

were the bones and teeth of two species of elephant, Elephas antiquus, and E. primigenius; the long-haired rhinoceros, R. tichorinus, the same species as that found by Pallas in frozen soil in Siberia; the cave bear (Ursus spelæus), the cave lion (Felis spelæa), the wolf (Canis lupus), the fox (Canis vulpes), horse, wild boar, badger, and weasel.

The Paviland caves were explored by Dr. Buckland in 1823, and Goat's Hole, the largest of them, furnished the remains of hyæna, mammoth, rhinoceros, bear and wolf, and associated with the bones of deer, ox, horse and some smaller animals, such as the rat and weasel. Above all these remains of cave animals were the bones of a Woman, lying in earth intermixed with pieces of limestone, and cemented and coated with stalagmite. The bones were stained by the red oxide of iron, and hence the name of the "Red Lady" given to the skeleton. Coins of the reign of Constantius, fragments of charcoal, and some ancient bone ornaments, were also found cemented together in this upper earth, so it is doubtful if the "Red Lady" dates back beyond the Roman period. There was a floor of stalagmite between the human relics and those of the extinct animals.

In Raven's Cliff Cavern, teeth of several individuals of Hippopotamus major, both old and young, were found, and this in a district "where," as remarked by Sir C. Lyell, "there is now scarce a rill of running water, much less a river in which such quadrupeds could swim." It is worthy of remark, that the old river drifts of the Avon at Cropthorne, near Pershore, afforded the bones and teeth of Hippopotamus major in considerable abundance to the researches of Mr. Hugh Strickland. These relics are now in the possession of Miss Strickland, at Apperley Court, and a fine tusk of Hippopotamus from the same river gravels may be seen in the Worcester Museum. So abundant in this locality were the remains of the extinct Mammalia, that on the occasion of a lecture given at Worcester by Mr. Strickland, it was suggested that Julius Cæsar brought wild animals with him to Great Britain, and that it was just possible they lived for

a time and then were drowned in crossing the Avon; while another theory was that a caravan of wild beasts had been upset in attempting to cross a ferry.

In Long Hole, Colonel Wood found some flint flakes associated with the remains of two different species of rhinoceros, the R. tichorinus, and the R. hemitæchus of Falconer.* These flint tools are undoubtedly relics of human workmanship, and furnish evidence that man was contemporary with the cave animals on the ancient land of Gower, as he was with the like wild beasts on the banks of the Wye, the Somme, the Lesse, or by the old rivers of Salisbury, and Bedford.

From Bosco's Den Colonel Wood obtained no less than one thousand antlers of the reindeer, chiefly of the variety called "Cervus Guettardi." They were mostly shed horns of young animals, and have been rolled and water washed; with these were the remains of the cave bear, wolf, fox, ox and stag.

Minchin Hole furnished the remains of the fossil Elephant, (E. antiquus), together with the bones, skulls, and teeth of the rhinoceros and ox. Two of the skulls of Rhinoceros belonged to the species R. hemitæchus. Some of the lower jaws of this quadruped were associated with marine shells encrusted on the matrix in which the bones were enveloped; these shells occurred at Minchin Hole in much the same position as were the flint flakes found in the Long Hole cave.

Bacon Hole was also worked out by Colonel Wood. At the bottom of the cave, on the rocky floor, was marine sand containing abundance of marine shells, Littorina rudis and L. litoralis, with bones of birds and field-mice. Above this bed was a layer of stalagmite, and over this again came a bed of black sand, in which was found a nearly perfect skeleton of Elephas antiquus, with remains of other animals. This sand was in fact filled with the bones of several individuals of this fossil elephant, among them being the humeri, femora, and phalanges. Over this was a bed of limestone breccia and cave earth, with bones and teeth of Elephas antiquus, Rhinoceros hemitæchus, Hyæna, cave Bear, wolf, ox and stag. Then

* See Lyell's "Antiquity of Man," p. 172, 513, &c.

came other layers in which were also found bones of the bear, bos, and stag; and above all, at the top, was a bed of alluvial earth, containing remains of the ox, stag, fox, and horns of the red deer and roebuck, as well as recent shells brought in by sea-gulls.* Some of the remains of these animals are in the Museum at Swansea, others are in the Museum at Stout Hall, the residence of Colonel Wood. Both these collections are well worth visiting.

The ancient name of Gower is derived from the word Gwyr, which signifies "a crooked country." The men of Gwyr are mentioned in Welsh records of very ancient date. Henry I. planted a colony of Flemings in Gower, who diffused industrial arts and habits around them, introduced the preparation and weaving of wool, and formed a border of defence against the Welsh.

Swansea Castle was built by Henry Beaumont, Earl of Warwick. It was attacked in 1113, by the Welsh under Gruffydd ap Rhys, but without success. We also learn from Leland that it afterwards became a part of the possessions of the see of St. David's, and was rebuilt by Bishop Gower, who was elected to that dignity in the second year of the reign of Edward III. (1328). He died in 1347. We are not aware that either Bishop Gower, or John Gower the poet, the "Moral Gower" of Chaucer, whose friend and contemporary he was, and the "Ancient Gower" of Shakspeare, had any connection with Gowerland. Bishop Gower was a native of Western Pembrokeshire which, as well as the peninsula of Gower, had been colonised by Flemings. The physique of the present inhabitants still bears the characteristic type of their ancestors. When travelling through Pembrokeshire we were struck with the contour of the head among all classes, the round cranium, the massive jaw, and the regular and beautiful teeth. These were also the marked characteristics of the skull of Bishop Gower, whose remains were discovered

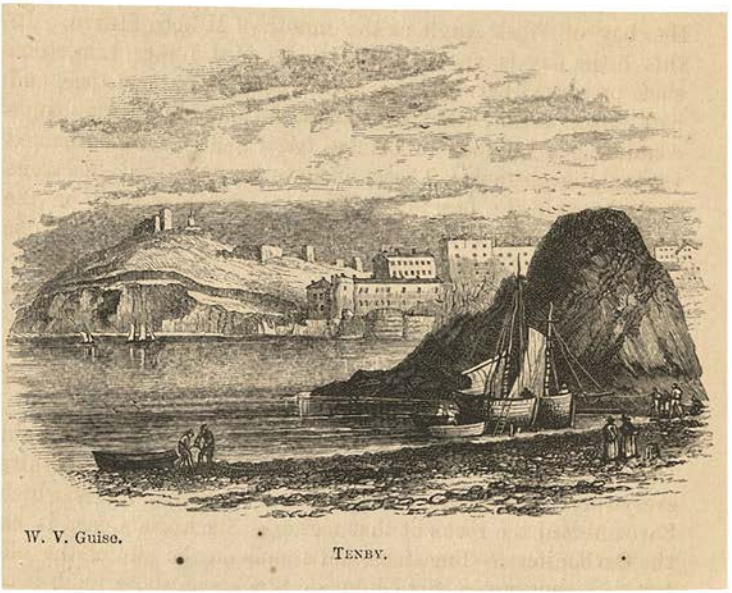
* An interesting account of this great cave and its remains of extinct Mammalia was communicated by Mr. Benson to the Swansea Literary and Scientific Society in 1851.

a few years ago during the excavations which were being carried on for the repair of the Cathedral of St. David's. The skull of one who was laid in the tomb only a few months after the great battle of Crecy, might well have passed as a typical example of a Pembrokeshire cranium of the present time.

The old Church of Swansea fell down in 1739, but the present building contains monuments of some interest. On one is an inscription which tells us that "Here lieth Sir Mathie Cradock Knight and my Ladie Katerine his wife." My Ladie Katerine was once the White Rose of England, the beautiful Lady Elizabeth Gordon, wife and widow of Perkin Warbeck. Oystermouth Castle (the place of armed men), not far from the Mumbles, is a fine ruin, and in the Coal shales near, the geologist may find specimens of the last of the trilobites, "Phillipsia," so named after the distinguished Professor of Geology for Oxford University. Swansea Bay, the "Sinus Tinbechicus" of Leland, is a great area of denudation between the land of Gower and the coast of South Pembroke.

Tenby stands on the upper beds of the Carboniferous limestone, which is much dislocated and dips to the south at a high angle. There are in fact long ridges of Old Red Sandstone, which have been elevated through the Mountain Limestone, and which strike across the country of South Pembroke from east to west. The Mountain Limestone or Lower Limestone shale has at the base a Bone bed, which, occurring at the junction of the shale with the Upper Old Red, occupies a position similar to that of the celebrated bone beds of Bristol and Tortworth. Sir H. De la Beche and Professor Ramsay have given sections of the junction beds at Skrinkle Bay. The Bone bed contains the teeth of several cartilaginous fish, such as Psammodus and Orodus, with scales of Palæoniscus. The Lower Limestone shales are charged with worm burrows often three inches broad and many feet in length. There is also a well marked group of Oolitic looking beds at the base of the Mountain Limestone with a series of thin cherty sandstones traversed by worm tubes which can be followed throughout

South Pembrokeshire, and which lie about seventy or eighty feet from the actual base of the Carboniferous shales. Corals are found in some abundance in the middle beds of the Mountain Limestone near Tenby, while the upper strata contain the characteristic Producti and other mollusca. The Coal



W. V. Guise.

TENBY.

measure sandstones lie to the north of Tenby, and their junction with the uppermost strata of the Mountain Limestone occurs near the Fish-market, the Castle Hill being composed of Mountain Limestone. The isolated rock known as the Goscar rock is a Coal measure, silicious, sandstone, and occupies the position of the Millstone grit.

Giltar is a fine mass of limestone rising perpendicularly from the sea to a height of 170 feet, and the Lydstep caverns, four miles from Tenby, should be visited for the sake of the interesting physical geology exhibited in the bays of Droch and Skrinkle. The Lower Limestone shale between Lydstep

Point and the Old Red of Skrinkle looks as if the stratification were absolutely vertical. Nevertheless, on examining the physical position of the beds we were satisfied that the true stratification is not vertical but that it owes this appearance to cleavage, the lines of which affect this Lower Limestone shale as it does the Carboniferous slates of Ireland and the strata at the bay of West Angle at the mouth of Milford Haven. In this little bay is an outlier of undenuded Lower Limestone shale preserved between two masses of Old Red Sandstone, and here also, Mr. Salter discovered nodular limestone bands containing a number of bivalve fossil shells which he named Curtonotus elegans. These bivalves occur in red limestone in beds near the base of the Lower Limestone shale on the south side of the bay. It is worthy of remark that the genus Curtonotus is *characteristic of the Pilton Group* of the Devonshire rocks across the straits. Mr. Salter correlated the lowest Carboniferous shales of South Pembrokeshire as the equivalents of the upper part of the Pilton group of Devonian deposits. I saw some of these Curtonoti in red limestone near Manorbeer Station.

The bold Coast cliffs of Stackpole display the Mountain Limestone much contorted. Indeed South Pembrokeshire everywhere shows the violence of the elevatory forces which have affected the rocks of that region. Stackpole Court is on the Carboniferous limestone and stands on the site of the old baronial residence of Sir Elidur de Stackpole whose tomb is to be seen in the beautiful church of Cheriton, and who is said to have gone to the Holy Land after the preaching of the crusade by Archbishop Baldwin and Giraldus Cambrensis. In Giraldus's time a spirit appeared in "the house of Elidore de Stackpole, not only sensibly but visibly, under the form of a red haired young man." "Whatever the master or mistress secretly thought of having for their daily use or provisions he procured with wonderful agility and without any previous directions, saying you wished that to be done, and it shall be done for you." On leaving Stackpole Court and walking to the cliffs we are struck by some remarkable fissures

in the rocks, especially at the Huntsman's Leap and Bosherton Meer. The little chapel of St. Govan (to which Sir Richard Hoare recommends all travellers in Pembrokeshire to make a pilgrimage, and which advice we heartily endorse) is built across one of these fissures, which is said to have been first rent to save St. Govan from his persecutors, and after enclosing him in safety, until the pursuit was over, again opened to let him out and never closed again. The Geologist soon ascertains one point, viz., that no upheaving of the coast, or submergence, or "convulsion of nature" of any kind has taken place at St. Govan's since this ancient structure was erected. The rocks have been stationary since that time, for this singular and rude little church is built across the fissure in such a manner that the slightest movement must have left traces of its effects. The rocks in the interior of the cleft also show marks of former coast action, when the salt waves must have washed into the hollow which afterwards formed the dwelling of a saint, and before the limestone of the cliffs had been upheaved to its present position.

Sir F. Madden observes that the traditions of the locality point out St. Govan's Head as the burial place of Sir Gawain, King Arthur's nephew, and attempts have been made to connect the old chapel of St. Govan in some way or other with this famous knight of the Round Table. I am heretic enough to believe that the chapel has been erected since the days of Giraldus Cambrensis, for he particularly alludes to these cliffs, when describing the falcons for which they are famous, and had St. Govan been already erected and become a noted chapel in his days, I imagine he would have mentioned so remarkable a structure among the rocks. This once venerated spot is now deserted by man, and, in the winter months, save a few sheep, and an occasional sea gull flitting past, all is still.

> "All's hushed except the sea fowl's notes,
> Hoarse murmuring from yon craggy brow."

During the summer the cliffs swarm with various kinds of Sea fowl, such as cormorants, razor-bills, guillemots, oyster

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ST. GOWAN'S CHAPEL, PEMBROKESHIRE.

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catchers, different kinds of gulls, and puffins. The Cornish chough (Corvus Graculus, Lin.) also builds occasionally among the noble cliffs between St. Govan's Head and the Stack Rocks. A few species of the hawk tribe still linger here, such as the kestrel (Falco Tiniculus) and the sparrow hawk (Falco nisus), but the Peregrine falcon (Falco peregrinus) is now extinct on this coast, having been harried to death by the game-keepers and pheasant-preservers. In olden days, Pembrokeshire was famous for these hawks, and Giraldus Cambrensis gives an account of the death of a Norwegian hawk which was let fly at a Peregrine falcon by Henry II., and was struck dead by the Peregrine "at the feet of the king." "From that time the king sent every year, about the breeding season, for the falcons of this country, which are produced on the sea cliffs."

Notwithstanding the extinction of some of the finest species of birds, every ornithologist and lover of nature should visit the haunts of the sea birds between St. Govan's Head and the Eligug Stacks. It is a sight to be remembered, for, in summer time, they are in such numbers that their flocks, for multitude, can only be compared to swarms of bees. When I was there the two lofty outliers of Mountain Limestone, known as the "Stacks," which stand out like isolated rock giants, and are yet within a stone's throw of the cliff, were thickly covered with birds. Before visiting the Stacks, Sir William Guise had engaged an egg-gatherer to go over the rocks in search of eggs and young birds. It was rather late in the season, but we saw the interesting performance of egg gathering, a boy being lowered by ropes slung under his arms over the craggy precipice of Bull Slaughter Bay. There was little real danger in the proceeding, as the ropes were strong and handled by experienced men; but looking on was giddy work, and the whole *coup d'œil* reminded us of one of Bewick's exquisite vignettes. There is a danger, however, at the Eligug Stacks, which may as well be mentioned, as I had a narrow escape myself. Lord Cawdor has fortunately forbidden shooting at, or disturbing by fire-arms, the swarms of sea fowl which

frequent the coast rocks, or no doubt, what has happened at Puffin Island, near Beaumaris, would occur here, and the birds would be persecuted, mangled, and destroyed. Still it is hardly possible to see the flocks of guillemots and puffins which cover the Stacks, apparently within a stone's throw, without jerking a pebble in hopes of persuading the multitudes, which are there sitting and screaming, to rise and fly. I had made one or two attempts at a long and strong throw, when my foot slipped and I had a heavy fall on the slippery grass with my feet over the precipice. Only a week afterwards, a number of school-boys went from Pembroke to the coast for a holiday, and one of them, in throwing a stone, lost his footing, shot over the rock, and was dashed to pieces. Among these cliffs we saw the beautiful Tree Mallow (Lavatera arborea) growing, but in nearly inaccessible places; our egg collector, however, sprang across a chasm, which would have puzzled an Anne of Geierstein, and returned in a few moments with a handful of the lovely rose-coloured blossoms, all the more valuable as being gathered in a truly wild locality. Arabis stricta grows on these cliffs near the Stacks.

The Bone Cave of Hoyle's Mouth, near Tenby, and some caves in the island of Caldy, were explored with great success by Mr. Smith of Gumfreston, and the Rev. H. Winwood during the summer of 1865. The caves on Caldy Island yielded the remains of the Mammoth, rhinoceros, hyæna, bear, horse, ox, deer, wolf, and fox, mingled with stone implements, flakes, and knives. Some years ago a cave was discovered at Caldy by quarrymen, which was so full of bones of the extinct mammalia that they were sent over to Devonshire as manure. The elevation of this cave was upwards of 100 feet above the sea. There was no external opening until the quarrymen blasted the face of the cliff, and the cave is now completely destroyed.* Caldy Island is an outlier from the rocks of Skrinkle.

Hoyle's Mouth furnished many organic remains to Mr. Smith's collection, and associated with them were several

* Paper on Tenby Bone Caves, by a Pembrokeshire Rector.

ancient flint implements of human manufacture. We were particularly struck with one very perfect "knife," which was derived from a peculiar green, pellucid, and compact silicious rock, with which we were altogether unacquainted. When examining Hoyle's Mouth, which is now an inland cavern, but which formerly opened out on an arm of the sea, we observed in the interior the marks of wave, or water action, at the end of the fissure, and we also found some well-rounded pebbles among the detritus on the floor. Mr. Smith possesses a portion of the jaw of that singular fish the Lophius piscator, which he obtained when quarrying the floor of the cave.

Remains of a submerged forest land are laid bare at low tides at several points on this coast. At Amroth the stumps of the oak and fir still remain, and they are often perforated by Pholades. The nuts of the hazel occur among the roots, and occasionally large trunks of trees are washed upon the beach after a heavy storm. Similar phenomena may be observed at Portclew and off the coast of Caldy Island, also at Swanlake Bay and at Whitsand Bay, near St. David's, as previously described. In short, there is little doubt that in a comparatively recent geological period forest lands occupied sites far out on both sides of the channel, where now the salt waves roll, as I have already said of Gower and other localities.

As regards Pembroke, we are told by Giraldus Cambrensis that the name "Penbroch signifies the head of the estuary," and that "Arnulph de Montgomery, in the reign of King Henry I., erected here a slender fortress with stakes and turf," which, on returning to England, he consigned to the care of Giraldus de Windesor.* Henry VII. was born at Pembroke Castle in 1457. Before gaining the crown of England this monarch was destined to pass through many a perilous adventure. Comines says:—"He told me, not long before his departure from France, that from the time he was

* Mason's Guide-book informs us that the castle was granted by Henry I. to Strongbow, Earl of Pembroke, but this is a mistake, as well as the statement that Giraldus visited Jerusalem. Archbishop Baldwin went to Jerusalem and there died, but not so Giraldus Cambrensis.

five years old he had always been a fugitive and a prisoner." Leland writes of Pembroke Castle:—"It standith hard by the waul on a hard rokke, and is veri larg and strong, being doble wardid. In the utter ward I saw the chambre wher King Henry VII. was borne, in knowledge wherof a chymmeney is new made with the armes and badges of King Henri the 7th."* It was dismantled during the civil wars.

Lamphey Palace was the episcopal residence in Pembroke of the Bishops of St. David's, and its erection has been generally attributed to Bishop Gower from 1328 to 1347. It is a good example of the domestic architecture of those times. The Palace, as well as Pembroke Castle, is on the Mountain Limestone. The Ridgeway is a good specimen of a massive wedge of Old Red Sandstone, formerly an anticlinal which throws off the Carboniferous limestone of Lamphey on one side, and that on which Carew Castle stands on the other.

The magnificent ruins of Carew Castle rest upon a mass of Mountain Limestone, which rises in a slight elevation above a narrow strait of Milford Haven. It was formerly one of the royal residences of the Princes of South Wales, and Rhys ap Tudor gave it as a marriage-portion with his daughter Nest, to Giraldus de Windesor, the chieftain before alluded to. The reception of the Duke of Richmond, afterwards Henry VII., by Sir Rhys ap Thomas, and the great tournament of St. George's day in 1488, are events connected with Carew Castle. It was dismantled in 1644.† The Geologist will observe that there can have been little or no change in the position of the land and the waters of the narrow estuary that flows at the base of the Castle rock. The beds of Mountain Limestone cropping out on the south side, below the little hill on which the Norman towers stand, have been untouched by the waters which for centuries have rolled on in their present course, and are sharp and angular.

* Itin., vol. v., p. 19.

† Lieut.-Col. Carew, of Crowcombe Court, near Taunton, is the owner of Carew Castle, and a descendant of the old family mentioned by Giraldus Cambrensis.

In examining the physical contour of the country around Chepstow, every geologist who has seen the Welsh rocks will arrive at the determination that the Carboniferous limestone which encircles Dean Forest and runs southward towards Newport was once continuous with the group of rocks which encircles the great Welsh coal basin. The neighbourhood of Chepstow, on the banks of the Wye, affords some fine sections of Mountain Limestone and the underlying rocks. The Old Red Conglomerate is exposed to the north of Tintern Abbey on the right bank of the river, and rises to the summit of Wentwood; affording here a striking lesson of the upheaval of the same beds, which in other localities, as at Symonds Yat near Whitchurch, dip into the Wye. In the succession of the Lower Limestone shale to the Upper Old Red, much the same characters are presented as those observed in the South Wales Coalfield. A good section may be traced out by going from Chepstow to Earlswood Common and Wentwood, and thence to Tintern Abbey. We thus pass from the Upper limestones to the *lower beds* which are exhibited between Well Head and Rugs Hole. Here there is a stream which, as is so often the case in the Lower limestone in Ireland, flows for more than a mile through a subterranean fissure. The passage from the lowest beds of the limestones into the underlying Old Red series may also be traced in this walk. There are few scenes in England more beautiful than the view from the summit of the Wyndcliff. Nine counties may be seen from the heights, and the river runs nearly 900 feet below, in a great fissure of Carboniferous limestone, widened by the denudation of the stream during long ages, and separates the bold escarpment of the rocks of the Wyndcliff from the frowning Bannagor crags. The geologist may learn a lesson from the summit of the Wyndcliff on the excavation of valleys along ancient lines of fault, for after studying these limestone sections he cannot suppose that these great gorges of the Wye owe their origin either to river or subaërial denudation alone, for a mere glance at the physical contour of the

country affords satisfactory evidence that the original dislocations were caused by earthquake movements acting on lines of fault, but which fissures have no doubt been since widened by marine, glacial, old river, and present river action, as well as by long ages of subaërial denudation, ages we may never reckon.

The neighbourhood of Chepstow is rich in historical associations and archæological lore. The town was known as Cas Gwent by the ancient Britons, and Strigoiel by the Romans. Charston Rock near Portscuett, is believed to be the place where the Romans, under Julius Frontinus, landed in the reign of Vespasian to attack Siluria and the Silures. Harold, the last of our Saxon kings, built a palace at Portscuett, at which he entertained King Edward the Confessor. In Doomsday Book, Chepstow Castle is mentioned as "Castillum de Estrighoiel." Part of the keep is of Norman architecture, and is supposed to have been built by William Fitz Osborn, Earl of Hereford, soon after the battle of Hastings. The later structure is generally believed to be Edwardian. Leland says, "A great likelihood ys that wen Carigent (Caerwent) began to decay then began Chepstow to flourish, it standeth far better as upon Wy, there ebbing and flowing by the rage cumming out of the Severn." It was taken and retaken several times during the struggle between Charles I. and the Parliament. The tower on the left of the entrance was for many years the prison of Henry Martin, one of those who signed the death-warrant of Charles I. I find Camden mentions a great inundation which occurred in January 1607, over the fenny tract below Chepstow, called the moor, which he says, "at my present reviewing these notes has suffered a most lamentable devastation." "For the Severn sea after a spring-tide, being driven back by a south-west wind, raged with such a tide as to overflow all this lower tract, and also that of Somersetshire over against it; undermining several houses and overwhelming a considerable number of cattel and men." Notwithstanding the power of these floods, they never deposited a single pebble like those of the old river

low level drifts, with their great rolled pebbles and their teeth and bones of the extinct mammalia.

Tintern Abbey stands on river alluvium, and from the position of some old drifts on the banks, I do not believe the Wye has altered its course to any extent since the year A.D. 600, when Theoderic, the British chieftain, fought a battle with the Saxon invaders of England in Tintern vale. The architecture of the far-famed Abbey indicates the transition from the Early English style to the Decorated, and our historical notes inform us that it was originally founded for monks of the Cistercian order in the reign of Henry I. (1131), by Walter de Clare, and dedicated to St. Mary. The building of the Abbey and the endowments thereof were carried on by Gilbert de Clare, surnamed Strongbow, the first Earl of Pembroke, and the conqueror of Ireland in the reign of Henry II. Strongbow married Eva, the daughter of Dermond, Prince of Leinster, in the midst of the desolation which followed the slaughter and harrying of the Irish after the siege of Waterford, when, as is recorded by Giraldus, "they entered into the city, and killed the people in the streets without pity or mercy, leaving them lying in great heaps; and thus with bloody hands obtained a bloody victory." After the death of Dermond, it appears that Strongbow took the title of King of Leinster, in right of his wife Eva daughter of the savage; and it is worthy of note that his submission to King Henry, before that sovereign embarked at Milford for Ireland, was made at Newnham in Gloucestershire, on the other side of the Forest of Dean. Among the sepulchral effigies is a figure of a knight in a coat of mail, which is supposed to be commemorative of Richard Strongbow, Earl of Pembroke, and is said before it was mutilated to have shown a hand with five fingers and a thumb; a physical characteristic of Strongbow. The Church, however, was not finished until 1257, and it appears that Roger Bigod, the celebrated Earl of Norfolk who withstood the commands of Edward I. in the haughty speech, "By God, Sir King, I will neither go nor hang," was the principal

founder of the ruined edifice of Tintern. On the Wye, below Penalt, are some *outliers* of Carboniferous limestone surrounded by Old Red valleys of denudation which are highly instructive as being the remains of denuded masses, which once connected the rocks of the Forest of Dean with those of the South Wales coalfield near Pontypool.

Whitchurch, a village about four miles from Monmouth, lies in the midst of a district celebrated for the beauty of its scenery and rich in features of interest for the geologist and botanist. In the great gorge between Whitchurch and the Mountain Limestone escarpment of Symonds Yat, flows the river Wye, thus cutting off the Doward Hills, and Coppet Wood Hill, which may be said to be outliers of Carboniferous limestone, from the great mass of Carboniferous strata of the Forest of Dean. There is evidence, as we shall see, that a stream which had its sources where the Wye rises, once flowed at a far greater height than the level of the present course of that river. For ages it has been deepening its channel, and dark craggy cliffs of Mountain Limestone clothed with rich foliage, now rise high above its waters. The hill of the Great Doward rises on the right bank of the Wye to the N.W. of Symonds Yat. A good section may be seen by ascending the hill from the Monmouth road, a quarter of a mile from the village of Whitchurch. The basement beds consist of Upper Old Red Sandstone, which thins out considerably in its southern strike from the Brecon Vans ; it is succeeded by the Old Red Conglomerate and the Passage beds of the Upper Yellow Sandstones, while the Great Doward itself is capped by the Lower limestone shale and the Carboniferous limestone. There are several caves on the Great Doward, and from their position, I hoped that, if opened up and examined, they might furnish the remains of some of the cave Mammalia; and some years ago, when exploring the cavern on the western slope of the hill, known as King Arthur's Cave, I was struck with the accumulation of cave earth in the interior, and endeavoured to obtain leave to make some excavations, but without success. However, in 1870, some miners engaged

in working for iron ore removed a good deal of the surface soil and cave earth, and in these excavations several fossil bones were discovered, which, when forwarded for examination to Professor Owen, were at once pronounced by him to be the relics of mammoth, rhinoceros, and horse; it was also clear from the state of the bones that the cave had been the resort of hyænas, as many of them had evidently been dragged in and gnawed. I then succeeded in obtaining permission, through the courtesy of Sir James Campbell, the Gaveller of Dean Forest, to carry on the exploration of the cave, and, assisted by a grant from the Malvern Field Club, we proceeded to institute a series of cuttings in order to ascertain the true position of the cave deposits. We were accompanied by Mr. Boyd Dawkins, the well-known osteologist, and we found the following was the order of deposition of materials in the Cave:—

1st. Fallen débris from the roof mingled with decomposed stalactitic matter and decayed vegetable matter, forming a superficial soil, which contained Pottery, considered by Mr. John Evans, the well-known Archæologist, to be probably British, and also unfossilised Human bones, and bones of birds, badgers, and foxes. In the interior of the cave, where the accumulations had been undisturbed, was a thin band of stalactitic matter, much decomposed, which, in all probability, had formed a thin stalactitic floor, the results of the droppings of water, charged with carbonate of lime from the roof. This separated the first layer of cave earth from the superficial débris above.

2nd. Earth, No. 1. This Earth was about two feet in thickness. In it were discovered flint flakes and chips, with three pebbles unmistakably chipped by human workmanship. Two of these are of black chert, evidently formed from rolled pebbles, while the third has been chipped, and is a pebble of some Lower Silurian rock. I excavated with my own hands one of the cores of chert from which flakes had been struck, and the second was found by my companion at the time, Mr. Scobell. Associated with these were the teeth and jaw of a Bear, with those

of the horse, and in Mrs. Bannerman's cave those of the Beaver.

3rd. Stratified Silt and Sand. Below this upper earth, and separated from it by a layer of thin stalagmite, we found a thick mass of *regularly stratified red sand and silt*, containing *some rolled river pebbles*. It appears to me that this stratified sand and silt with its rolled pebbles, tells its own history, for I cannot account for its accumulation excepting by the supposition that they were introduced into the cave by the action of a stream which once flowed at a very different level from that of the present Wye, and which had access to the cave in former ages. The river indeed now flows more than 300 feet below the mouth of the cave; but those acquainted with the geology of the Wye, will readily recognise these pebbles as belonging to the silt of an ancient stream which, in those days as now, must have had its source in the heights of Plynlimmon, and washed down those cave stones from the Lower Silurian and trap rocks of Rhayader and Builth, a distance of seventy or eighty miles from the cave's mouth.

4th. Here a floor of stalagmite, about two feet thick, occurred, underneath which we came to a second accumulation of Cave earth.

5th. Cave earth, No. 2. This Cave earth contained a great number of bones and teeth of the Rhinoceros, and fossil Horse, the teeth and horns of the Reindeer, the teeth of the Irish elk, and Bison, teeth and jaws of the cave Lion, Hyæna, and the teeth of the Mammoth (three sizes and ages), and here and there we disinterred some *flint flakes*, principally from the upper layers. One or two of these flakes I discovered myself *in situ*, imbedded with the bones of the mammoth. It is not, however, the association of the bones of the extinct animals with the rude flints of ancient Men,* that tell us more than do other caves of the antiquity of the history with which we have to deal. It is the fact of the Cave earth with its relics of the presence and handiwork of Man, and its remains of the extinct

* On this subject the reader is referred to Sir John Lubbock's "Prehistoric Times," and Mr. Evans's work "Ancient Stone Implements."

Mammalia, being sealed with the thick floor of stalagmite, and the stratified sand and gravel of an ancient stream; which overlies this stalagmite, and which must have been deposited by waters which flowed 300 feet above the present level of the river, which stamps the antiquity. The Mountain Limestone gorge between Symonds Yat and the Great Doward, has been excavated since those old men of Herefordshire chipped their flints and river pebbles when sheltering awhile in the hyæna's den; and it is probable, too, that the soft Old Red strata north of the Great Doward once rose higher than the harder limestones of the Dowards, and that long ages of atmospheric denudation have reduced their height since the days of the Cave Men and extinct Mammalia. Other excavations during the present summer (1872) have not induced me to alter my opinions respecting the introduction of the Wye silt and pebbles into this cave. Nor is the history very different from that presented by river action at the caves on the Lesse, in Belgium, where a *human jaw*, associated with remains of rhinoceros, was found under somewhat similar conditions. My friend Mr. Scobell, of Doward House, succeeded in finding a large humerus of mammoth, and some fine molars of Rhinoceros tichorhinus, in a cave belonging to Mrs. Bannerman, fifty feet higher than is the cave of King Arthur. In the upper débris of this cave was found a perfect lower jaw of a beaver, probably one of the last of those animals that frequented the banks of the Wye.

There are many quarries on the Great Doward, some of which have yielded large tuberculated ganoid scales, and portions of the spines of Ctenacanthus, also fragments of teeth, known as Orodus, of a Cestracion fish. Several rare plants flourish on this hill, among them are the Fly Orchis, Bee Orchis, Carex Montana, Aquilegia vulgaris, Arabis strieta, Geranium sanguineum, G. lucidum, &c., and also a curious form of Rubus, mentioned by Mr. Edwin Lees, in his "Botanical Looker Out," under the name of "Rubus Ballidus." The Great Doward is the home of the well-known cave dweller of modern days, "Jem the Slipper," under whose

guidance I first visited the hyæna's den and the other caves.

The Little Doward Hill lies to the west of the Great

W. V. Guise.

JEM THE SLIPPER.

Doward. The remains of an old encampment are very conspicuous on its summit, and, according to Gibson's Camden, "broad arrow heads" have been found here, and a human skeleton, "whose joints were pretended to be twice the length of those of the present race."

The geologist should not fail to visit the New Weir on the

Wye, and examine the fissure through which the river flows, and which forms a regular chasm between the Dowards on the right bank, and Symonds Yat on the left. From Symonds Yat the view is romantic in the extreme, while the dislocations of the earth's crust, which have taken place in this district, are well shown forth in the range of Mountain Limestone by Ravenscliff, with the dipping masses of Old Red Conglomerate, along Coppet Wood Hill, on the opposite side of the river. Symonds Yat is an excellent station for the rarer limestone plants and ferns. Polypodium Dryopteris and P. calcareum both grow among the cliffs, and Campanula patula, Geranium sanguineum, Pyrus Aria, Rubia peregrina, and Tilia parvifolia. I have also seen Aquilegia vulgaris (the wild columbine) growing truly wild in the woods.

On the broad pathway, leading from Symonds Yat to English Bicknor and Lydbrook, stands a large Boulder of Coal Measure Sandstone. It was enveloped with others in a mass of angular and sub-angular drift, which, I believe, owes its transportation entirely to the ice agencies of an ice epoch, to which I have already alluded, viz., the period of cold which affected Great Britain for long ages after the land had assumed much the same physical configurations as at present. The origin of these drifts can hardly be attributed to the epoch of the great Glacial depression of Great Britain, and that of the sub-marine boulder drifts; they belong to a later stage of the glacial epoch, to the time when glaciers occupied the hollows of the mountains, when, even in our lowlands, perennial ice and snow covered every hill side, and filled every vale, when winter protracted his stay far into the spring, and the melting snow and ice of every summer forced the masses, lifted by winter frosts, inch by inch, and foot by foot, downwards towards the vales. I believe that when the Machen boulder made its first start from its mother rock, a glacier filled the Coomb, on the summit of the Brecon Vans, and great sheets of ice and snow swept from the flanks of the Malvern Hills down to the vales; that sub-arctic plants grew on what is now the land of Dean Forest, and the cloudberry

(Rubus Chamæmorus) blossomed where now flourish the elm, the oak, and the ash ; while the woolly-haired Rhinoceros, the long-haired Mammoth, and the Reindeer wandered where now may be seen only the rabbit and the hare. I have called the Boulder the Machen boulder in remembrance of a gentleman (the Rev. Mr. Machen of Staunton) who, at my request, preserved this geological relic from destruction when it was on the point of being destroyed.

ORGANIC REMAINS OF THE CARBONIFEROUS LIMESTONE.

In many localities, the Mountain Limestone is very rich in the remains of marine animals. The corals are declared by M.M. Milne Edwards and Jules Haime to display a peculiarity of structure which distinguishes them from the Neozoic corals, or from those species found in rocks newer than the Permian. The Bryozoa and Crinoidea are also numerous in the Mountain Limestone, and the collection of Mr. Wood of Richmond, in Yorkshire, is especially rich in beautiful crinoids. The genus Palœchinus is the analogue of the modern Echinus. Dr. Wright of Cheltenham, Vice-president of the Cotswold Club, possesses a wonderful collection of the Echinodermata and the genera characteristic of various formations.

Mr. Etheridge enumerates eighty-six genera, and upwards of 650 species of Mountain Limestone shells, of which the most characteristic are the large Producti and Spirifers, with a certain number which belong to existing genera, as Avicula, Nucula, Solemya, and the boring shells, Lithodomi. The modern glass shells (Carinaria) are represented by more than twenty species of Bellerophon. The Cephalopoda of the Carboniferous limestone are represented by the straight forms of Orthoceras and the coiled Goniatite, which looks like a Nautilus, but has its siphuncle in a different position, and belongs to the Ammonites, not the Nautili. Fish must have been abundant, as there is a "bone bed" known as the Bristol bone bed, almost made up of fragments of fishes. Many of the teeth of these fishes are similar in form to those of the Port Jackson shark, a Cestracion; and are palatal teeth,

adapted to crushing and grinding, and set in the jaw like tesselated pavement. Some of the teeth are similar to those of common sharks, and were set in massive and powerful jaws. The defensive spines and fin-bones of these fishes are sometimes found very perfect. The Earl of Enniskillen possesses a wonderful collection from the Carboniferous limestone of Ireland.

The Earl of Ducie possesses the finest ichthyodorulite from these rocks I ever saw. He obtained it from the limestone of Clifton, near Bristol. These fish-spines are known under the terms of Oracanthus, Ctenocanthus, Orodus, &c. Some of these spines are believed by M. Agassiz to be the spears of fish allied to our modern sting ray (Trygon), which has on the tail a strong spine, notched on each side. The great Megalicthys Hibberti has a very reptilian-looking mouth and teeth; and the palæontologist cannot help remarking the difference between the small spines and teeth of the Upper Silurian and Old Red fishes, when compared with those of their far more gigantic successors of the Carboniferous epoch.

The Trilobites of the Silurian rocks appear to have been rapidly passing away as representatives of crustacean life, for very few forms pass upwards from the Devonians, and would seem in the Carboniferous period to have died out altogether.

OF THE BONE CAVES, BANWELL.

CHAPTER X.

CARBONIFEROUS ROCKS.

Millstone Grit—Area of—Deposition of—Conglomerate—Watt's and Offa's Dykes—Oswestry—Whittington Castle—Tournament at the Castle of the Peak—Carreg-o-gof—Fault of—Section near Ross—Boulders near St. Bride's Bay—Coal Measures—Historic Notes on Coal—Palæozoic Coalfields—Formation of—Carboniferous Flora—Chemistry of Coal—Coalfield of Anglesea—of Flintshire—Basingwerk Abbey—Denbighshire—Holt Castle—Church of Bangor Iscoed—Rocks of Haughmond—Bitumen—Haughmond Abbey—Clee Hills—Forest of Wyre—Rare Plants of—Coalbrook Dale—Fossil Fishes of—Coalfield of Forest of Dean—of South Wales—"Patch Working"—Pennant Grit Series—Neath Abbey—Former Continuity of the Coal Measures—Organic Remains of the Coal.

		Plants.	Organic Remains.
1. Coal Measures.	Shales and Sandstones. Coal Measure. Coal. Sandstones. Coal. Shales. Sandstones. Coal Measure.	*Ferns.* Pecopteris. Neuropteris. Caulopteris. Lepidodendron Sternbergii. Lycopodium densum. Calamites. Sigillaria, with Stigmaria. Conifers.	*Fish.* Rhizodus. Cœlacanthus. Megalichthys. Gyracanthus. Cochliodus. Hybodus. *Reptilia.* Labyrinthodon. *Land Shells.* Pupa. Helix. *Insects.* Dragon flies. Spiders.
2. Millstone Grit.	A quartz rock, often passing into a conglomerate in a siliceous matrix. It is sometimes 600 feet thick.	Occasional impressions of plants.	In North Wales it affords some badly preserved fossil shells of Mountain Limestone species.

IDEAL VIEW OF THE VEGETATION OF THE CARBONIFEROUS ERA.

MILLSTONE GRIT.

THE geologist cannot fail to observe the remarkable difference in the mineralogical characters of the Mountain Limestone and the overlying Millstone grit, which was thus named from being formerly much used for millstones, and the grinders of cider mills. So great is the difference in the mineral nature of these Carboniferous rocks, that we are led to inquire into the causes to which we may attribute this change, for the Millstone grit, although sometimes absent, like the Mountain Limestone, occupies a large area over Great Britain and the Continent. In the western districts of North Wales, it is found principally as outliers, and here and there in patches, overlies the Mountain Limestone, as near Llandudno, thus showing the great denudation which has cleared away much of the intervening strata of this hard unyielding rock, once so continuous over this area. It overlies the limestone of the great South Wales coalfield, and ranges from Carmarthen into Pembrokeshire. It occurs in the same situation in the great outlier of Dean forest; and in Derbyshire, the west of Yorkshire and Lancashire swells into a thickness of 600 or 800 feet.

The Upper Carboniferous limestones of the midland and southern districts of Ireland, are surmounted by the equi-

valents of this rock, and Sir Roderick Murchison traced them even into Germany and Spain.

In some localities in the Silurian region, the Millstone grit partakes of the character of a coarse conglomerate, and in hilly districts where the Old Red conglomerate has been also exposed

GENERAL RELATIONS OF THE CARBONIFEROUS ROCKS IN THE CENTRAL AND SOUTHERN PARTS OF ENGLAND.

a, Upper beds of the Old Red Sandstone (Devonian). *b*, Sandstone and Lower Limestone-shale. *c*, Carboniferous Limestone. *d*, Millstone-grit. *e*, Coal and iron-stone. *f*, Main Coal-measures. *g*, Upper Coal, with a peculiar Limestone. *h*, Red Sandstone (base of the Permian Rocks, here represented as conformable to the Coal, but usually transgressive.)

and denuded, it is difficult to the unpractised eye to determine to which conglomerate the boulders or rock fragments belong. It is evident that the Mountain Limestone must have been deposited under very different circumstances to those which brought about the deposition of the Millstone grit, which, where it contains rolled and water-worn pebbles, probably the result of powerful currents, may have formed sea-beaches, while the limestone must have been segregated in deeper and tranquil waters. The limestone often consists of one mass of the segregations of coral animals, and contains shells, and fishes of marine origin. In the Millstone grit, the elevation of the old bed of the ocean was apparently going on, for we meet with no corals and few shells: while the remains of land plants are not uncommon, and especially in the South Wales country we often see the impressions of Carboniferous trees and plants imbedded in the old sea grits, which were afterwards to be covered up by the vast accumulations of the Coal-measure period. In the Silurian region, this rock is commonly known as the "Farewell Rock," or "good-bye" to the coal seams when once it is reached by the boring rod.

In Derbyshire, and the eastern districts of the Carboniferous

rocks of England, the Millstone grit is underlaid by a series of black shales called the Yoredale Rocks. They are full of marine fossils, and especially abound in stems and remains of encrinites, or stone lilies, which form beds of limestone, extending often for many miles on their strike, in every direction.

When rambling in the vales of Monmouthshire, among the debris of the rocks which lie scattered in boulders over the hills, the geologist will be struck with the abundance of Millstone grit boulders in localities where we should expect to see boulders of Mountain Limestone occurring at least as plentifully, whereas they are extremely rare. I mentioned this on one occasion to a friend who knew much of the chemistry of rocks, and he remarked that during long ages of subaërial exposure, the fragments of exposed Mountain Limestone would dissolve through atmospheric agencies, whereas the Millstone grit would yield far more slowly.

A Millstone grit country is, as a rule, sterile and bleak, and the naturalist and botanist are glad to leave it for a limestone district. It affords very few fossils, and is the habitat of few good plants; thus the lover of physical geology alone cares to bestow upon it any examination in detail. There are, however, some localities where interesting lessons may be learned regarding the position of rock masses, and denudation, from these deposits. In the north-eastern portion of North Wales the Millstone grit may be seen well developed in the south east of Denbighshire. It caps the summit of the Eglwyseg rocks, near Llangollen, and there it is fossiliferous, yielding stems of encrinites and casts of shells, which have the appearance of being derived from older beds. It may be seen also at the Trevor Rocks, where there are casts of fossils that look as if they might be casts of Producti, washed out of the Mountain Limestone.

Sir Roderick Murchison in his "Silurian System," divides the Millstone grit of Oswestry into three series, but this does not hold to the westward, as this rock varies much in its lithological characters. In the neighbourhood of Oswestry, these deposits occur at Selattyn and Porkington, also on the summits of Cern-y-bwch and Mynydd Myfryr. Sir Roderick

gives a section through the Millstone grit of Mynydd Myfryr, indicating the position of the different strata ; * he notices also the fossiliferous character of this rock in Shropshire, and the red strata associated with its white and grey sandstones. The lowest beds of the formation may be observed in the promontory of Sweeney Mountain, and on the west in the hills of the Race course.

The Millstone grit of the Flintshire coalfield differs from that rock in the South Welsh coalfield, in being more of a silicious sandstone, and containing more organic remains. These are evidently of marine origin, inasmuch as Orthoceratites, Producti, Lingulæ, and Orthides, with Rhynconella pleurodon, have been found in abundance by Mr. W. Prosser,† at Sweeney near Oswestry. With these occur occasionally the remains of Coal plants, such as Sigillariæ. It appears also as if, in some localities of the Flint coalfield, the Millstone grit had either not been deposited, owing to currents sweeping along the edges, or else had been denuded before the deposition of the coal measure shales; for at Selattyn Hill, five miles from Oswestry, the coal shales lie unconformably, and without the interposition of the grit, on Silurian slate rocks.

The visitor to Selattyn should not fail to mark the position of Offa's Dyke, the old line of demarcation already spoken of, between the kingdom of Mercia and Wales. It may be seen three miles west of Gobowen, while to the east of Belmont is *Watt's Dyke*, another ancient boundary, which commences three miles south of Oswestry, is nearly parallel with Offa's Dyke, and runs northward into Flintshire. Churchyard, writing of these two Dykes, says :—

> "There is a famous thing
> Callde Offa's Dyke, that reacheth far in length,
> All kind of ware the Danes might thether bring ;
> It was free ground, and callede the Briton's strength.
> Wat's Dyke likewise, about the same was set ;
> Between which two both Danes and Britons met."

* Silurian System, p. 144. † Geol. Mag., vol. ii., p. 107.

Oswestry stands on the site of a very ancient town in the district between Watt's and Offa's Dykes. The Saxons called this place Macerfelth, or the field of acorns; and the Welsh called it Croes Oswalt (Oswald's cross) in memory of Oswald, King of Northumberland; who was slain there and his body nailed to a cross by Penda, King of Mercia, A.D. 642. A little distance from the church is a well, still called Fynnon y Capel Oswalt. In 1212 King John burnt the town and castle, and, as his habit was, plundered the place and people. In 1644 the Royalists destroyed the Church tower. In the town there still remain some of the old timber houses that stood in the days of Queen Elizabeth, and Churchyard, who says of "Oyestri,"

> "It stands so trim, and is maintayned so cleane,
> And peopled is with folke that well doe meane,
> That it deserves to be enrouled and shryned
> In each good heart and every manly mynd."

About a mile to the north, to the right of the branch railway to Gobowen, is the Hen Dinas of Camden, also called Caer Ograu and Old Oswestry. It is a British camp, defended by a deep triple entrenchment. At Porkington there is another entrenchment on the west side of the Park; and both here and at Selattyn Hill, Henry II. is said to have lost a great number of men in his raids on the Welsh.

From Oswestry the ruins of the Castle of Whittington may be visited. Nightingale, in his account of Shropshire, says that after the Conquest it was held by Roger de Montgomery; and afterwards by Peverell of the Peak of Derbyshire, who offered his daughter Mallet in marriage to the Knight who should display the greatest prowess in the tilting court. The Castle of the Peak was the tilting ground; and there entered the lists *Guarine de Metz*, of the house of Lorraine, Lord of Alberbury and sheriff of Shropshire. He entered with "his silver shelde, and a proude pecock upon his heaulme creste," overthrew his rivals, won the Ladye, and received the castle of Whittington from Peverell of the Peak,

as her dower. Fulke Fitz Guarine, a descendant of Peverell's daughter and Guarine de Metz, was one of the barons who forced King John to sign Magna Charta. Among the ruins are remains of eight towers, four of which belonged to the keep, and it is evident that in feudal times it was a place of great consequence.

> "In ancient days of high renown
> Not always did those castles frown
> With ivy-crested brow;
> Nor were their walls with moss embrowned,
> Nor hung the lanky weeds around,
> That fringe their ruins now."

In clearing the bottom of one of the towers about 1812, some huge iron fetters were found, a gyve of ponderous size, and numerous heads and antlers of red deer. When visiting these ruins some years ago, I knew nothing of the history of this once important border fortress; and it then struck me how useful to the rambling geologist would be a few historical notes upon the remote old places where neither Pennant, nor Gough's Camden, can be obtained, and it was then that I determined to search in Old Records for some account of the ancient ruins I might come across when rambling in pursuit of fossils or physical geology. I have never regretted the combination of historical with geological lore, nor have I ever found the one interfere with the other.

Travelling in a north-westerly direction the Millstone grit may be seen on the Hope Mountain* south of Mold. At Caergwrle, a mile to the south, Roman tiles, bricks, beds of iron, scoriæ, and bits of coal, have been found. The gorge of Alyn below Caer Estyn is romantic, and Gresford is a lovely village, with a church remarkable for its bells, its ancient monuments, grotesque mouldings, and its tower.

At the Titterstone Clee, the Millstone grit formation consists of a pebbly silicious conglomerate, similar to that of the South Wales coalfield. It is best seen on the north side of the road

* Hope Mountain may be best reached from Chester, going to Hope station.

to the Carboniferous quarries of Oreton, and its boulders strew the hill all the way down the slopes. It may be seen in position above the limestone at Knowl. Impressions of coal plants occur in the scattered blocks on the north side of the hill, and here and there great boulders of this rock are stranded far down the valley.

In the counties of Glamorgan and Monmouthshire, the Millstone grit appears in many localities in situ supporting the Coal measures of the South Wales coal-field, and is strewed in every direction as boulders on the hill sides, Varteg Hill, near Pontypool, being covered with them. The most picturesque situations, however, and the most instructive are Pen Cerrig Calch, the great outlier on the Black Mountains already alluded to, nearly 200 feet of Grit covering the Mountain Limestone of that isolated peak; and the hill of Carreg-o-gof near the Van-sir-gaer of the Vans of Caermarthen. Here there is a grand fault, the Old Red of the Van-sir-gaer rising 2300 feet above the sea, while the neighbouring hill of Carreg-o-gof, covered by Millstone grit and Mountain Limestone, is thrown down on the west, and rises only to about the height of 1400 feet. A little stream runs along this line of fault. The lake at the base of the Old Red of the Van-sir-gaer is dammed up by a small moraine of Old Red Conglomerate; while the walk across the moors over the Old Red to Trecastle shows a multitude of boulders of Millstone grit which must have been denuded from the eroded summits of the Caermarthen Vans.

The fault that throws down the picturesque rock upon which Castell Cerrig Cennen near Llandeilo stands, is well illustrated by examining the Millstone grit on the left bank of the Lwchwr stream beyond an old farm house, and comparing its position and strike with that of the Old Red Conglomerate on the right bank, where, near Cennen house, it underlies the Mountain Limestone which supports the ruined castle.

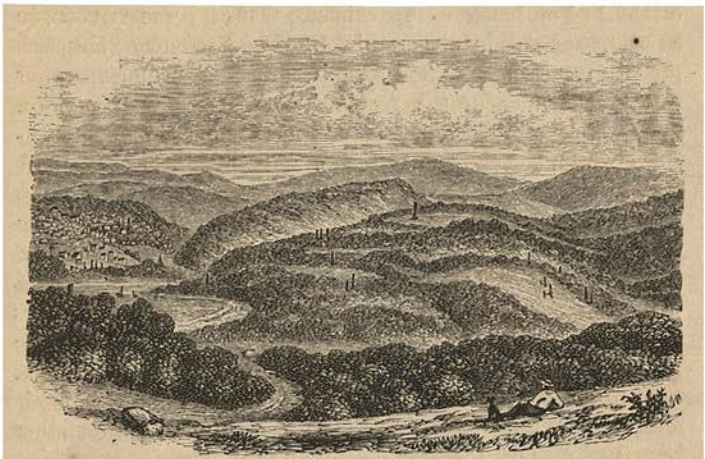
In the Forest of Dean district, there is an instructive section within a walk of the town of Ross. It may be reached by going from the Ross and Lydbrook road by Whythall (the residence of Mr. Collins, a picturesque old manor-house

occupied by Cromwell during the siege of Goodrich Castle) and ascending towards the Forest by Kiln Green and Dundle Hole. The Millstone grit lies over the wild district known as Howl Hill, Egypt, and Howl Green, and on the grit rests a thin seam of the lowest coal measures; the upper coal seams of the Forest being here denuded. This is a dreary country as compared with the beautiful Old Red Sandstone vales, but presents an outlier of the Coal measures as it is separated from the regular Dean Forest coal measures at Ruardean, by a mass of Carboniferous limestone which intervenes, and from above which the Millstone grit and coal are denuded. Beyond Symonds Yat these rocks may be seen by following their strike by Braceland and Scowles' Farm to Coleford; and near Monmouth is High Bury, an outlier and regular island of Carboniferous rocks, surrounded by Old Red Sandstone,—a Pen Cerrig Calch on a smaller scale.

In Pembrokeshire the Millstone grit is a whitish, silicious rock like that of Caermarthenshire, and to the east of the estuary of Milford Haven the Coal measures may be seen underlaid by great masses of this silicious grit and Mountain Limestone. The grits occasionally contain stems of Calamites and Lepidodendrons as at Amroth near Tenby. Westward of the estuary of Milford Haven the Mountain Limestone thins out; but all along the coast-line I observed great masses of silicious Millstone grit stranded as boulders on the escarpments of the cliffs of St. Bride's Bay. At a place called Haroldstone there is one of especial size and well worthy of notice: it rests on Culm shales instead of under them, as is its proper position. It is not always easy to determine these rocks from coal measure sandstones by their mineralogical character. This was shown in 1864 by Mr. Handel Cossham, F.G.S., who read a paper at the meeting of the British Association in that year, which proved that the supposed Millstone grit of Kingswood Hill, Bristol, instead of lying below the productive coal measures and being a Farewell Rock, was in truth a coal measure sandstone having twenty-one seams of coal lying in regular order below it.

THE COAL MEASURES.

Coal is now so intimately associated with the future destinies of Great Britain as well as with our ideas of comfort and enjoyment, that it is not surprising if some of us believe



VIEW IN DEAN FOREST, NEAR RUARDEAN.

that there is something in the history of its composition, storing, and preservation through an interminable series of ages and mutations, which must be referred to a scheme of Providence and Design rather than to a blind collection of vegetable matter which grew by chance, was accumulated by chance, and was turned into coal by chance. Some persons ignore all ideas of Providence and design in the bygone history of our planet, and attribute the accumulation of such terrestrial treasures as our coalfields to a series of blind laws; while others believe in the forethought of that Providential care which elaborated them for the use of Man. I prefer the latter theory.

The question of the exhaustibility of our Coal-fields is highly complicated, and I refer my readers to the excellent treatise on

this subject by Prof. Hull, Chief of the Geological Survey of Ireland, on "The Coalfields of Great Britain." Referring the Coal mentioned in the Bible to charcoal, Mr. Hull observes that Theophrastus, who lived about 240 years before the Christian era, describes actual coal in definite language, while it is established on incontestable evidence that coal was worked, to a certain amount, by our pre-historic British ancestors, although the vast forests of England supplied an abundance of wood for fuel in the days of the Anglo-Saxon and Norman periods. Stone implements have been found in old mines in Monmouthshire, and at Ashby-de-la-Zouch. Again, Mr. Hull remarks that the Latin proverb quoted by Phædrus, "Carbonem ut aiunt pro thesauro invenimus," loses all its significancy if considered as referring to *charcoal*. Cinders have been found among the ruins of Roman towns and villas, as at Caergwrle near Chester, already alluded to, and some years ago I saw several fragments of coal lying about on the site of Ariconium, near Ross; while at Uriconium, or Wroxeter, coal has been found in the flues. Whittaker, also, in his "History of Manchester," relates instances of the association of coal cinders with Roman remains and coins.

In the Anglo-Saxon period it is probable that coal mining was practised to some extent, as the Saxon Chronicle of the Abbey of Peterborough records that about A.D. 852 the Abbot Ceolred let the land of Sempringham subject to the delivery, among many other requisitions, of twelve loads of coal. The term coal is identical with the Saxon or German "kohle," and appears to have superseded the British name "glo."

References to coal are made in the Boldon Book in the time of Henry II.; and in the reign of Henry III., 1259, a charter was granted to the freemen of Newcastle-on-Tyne for liberty to dig for coals.

The Coal pits of Bychton and Mostyn in Flintshire had been discovered in the days of Edward I., for they are mentioned in a deed issued in the twenty-third year of his reign, and in the latter part of the fourteenth century collieries were opened in many parts of Great Britain. In Elizabeth's time coal had

become an important source of revenue, and Camden mentions coalpits being on fire in Scotland! The importance of Coal in a national point of view can only be estimated by reflecting on what would become of Great Britain without the agent which warms our hearths, heats our forges, smelts our metals, illumines by its gases at night our cities, streets, and dwelling-houses, propels our locomotive engines and carries thousands of steam vessels, often against the storm wind, over the most distant seas.

There is little doubt that the physical conditions of the Palæozoic Coal period must have been very different to those under which we now live; but it must not be supposed that the accumulation of coal was altogether limited to that epoch. The Coalfield of Virginia in America extends from north to south for a distance of nearly thirty miles, and is from four to twelve miles in breadth. The plants of which that coal consists have the nearest affinity to those of the European Trias, and the coal seams often surpass in thickness those of the Primary or Palæozoic formation. The "Brown coal" of Switzerland and Germany is of the age of the Middle Tertiaries; and at Wildsfluth in Austria coal is worked which is probably of still later date. Nevertheless the geographical area occupied by the Palæozoic coalfields is very remarkable, and none of the later accumulations of this mineral can be said to be strictly analogous. In the United States of America the Primary coalfields cover more than 600,000 square miles, or a tract of nearly seven times the size of Great Britain. The vegetation of this great formation must also have extended over many latitudes and longitudes, for Coal plants once grew in the area of Melville Island, in 75° north latitude, where there is little else now but ice and snow. Fossil coal-plants have been found in localities as distant as Spitzbergen and Peru, and the same species of plants occur scattered over areas which are altogether at variance with the present distribution of vegetable life.

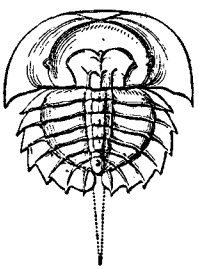
There has been much dispute on the subject of the *formation* of Coal, and the way in which such enormous masses of

vegetation were accumulated; whether they were drifted by rivers and deposited in estuaries or lakes, or whether the plants grew, as in recent peat mosses, jungles, and cedar swamps, and gradually sank and were covered up by layers of mud and sand, while fresh masses of ferns, club mosses, &c., again grew on the new surface, to be in their turn submerged, until subsidences and accumulations of mud and silt overlaid as many successive vegetable areas as there are seams of coal in our various coal-fields. The Great Slave river of North America, carries down enormous masses of drifted trees and timber into the Slave lake, where the wood becomes waterlogged, sinks, and is covered by sediment; and the great swamps of the Mississippi of Louisiana and Nova Scotia have been considered as somewhat analogous representatives of the character of the ancient forest vegetations, and of the conditions which formed our coal-fields.

Perhaps the "Sunk Country" of the Mississippian valley, so graphically described by Sir Charles Lyell, and which was submerged by an earthquake in 1811—1812, is as good an example as we can bring forward of recent physical conditions under which lacustrine, or fresh water coal-beds, may accumulate, although it will not apply to those seams of coal which are interstratified with beds containing organic remains of marine animals, which must have been inhabitants of sea coasts and margins. When Sir Charles Lyell visited the "Sunk Country" he observed erect trees which had been standing ever since the earthquake and submergence of the area; lacustrine and swamp plants growing in the shallows; and an immense amount of swamp vegetation accumulating; also that this great morass was surrounded by so dense a marginal belt of reeds and brushwood, that although several rivers have annually inundated the whole space, no sediment whatever has been carried by the waters into the vegetable morass within. "The dense growth of reeds and herbage which encompasses the margins of forest-covered swamps in the valley and delta of the Mississippi, is such that the fluviatile waters in passing through them are filtered and made to

clear themselves entirely before they reach the areas in which vegetable matter may accumulate for centuries, forming coal. If the climate be favourable, there is no possibility of earthy matter in such cases."* But if some of the strata of the coal measures are of fresh water, recent investigations prove that a large portion of the deposits associated with coal are of marine origin.

LIMULOID CRUSTACEAN OF THE CARBONIFEROUS PERIOD.



Prestwichia otundata (Limulus, Prestwich.) From the Coal-measures of Coalbrook Dale.

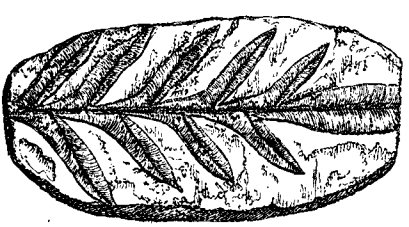
The observations of Sir William Logan, when surveying the South Wales coal-field, established the fact that the plants which formed the coal grew upon the spot where they are now found changed into coal, and that the underclays, which are penetrated by Stigmariæ (the roots of Sigillariæ), formed the actual soil on which those great club mosses grew. One of the remarkable points connected with some coalfields both in England and America, is the displacement, faulting, submergence, and re-elevation of the coal-bearing rocks. It has been calculated by Mr. Hull "that in the case of the coal-field of South Wales, every bed of true coal represents a land surface, or at least a former sea level, and that the vertical displacement which the South Wales coalfield underwent, was nearly sufficient to have brought the summit of the Alps to the

* Lyell's Visit to the United States, vol. ii., p. 245.

sea-level. The geologist who really studies the physical history of this Coalfield, feels the impossibility of comprehending the time necessary for the fulfilment of the phenomena he there beholds; viz.—the evidence of slow and gradual subsidence accompanied by a series of pauses in that subsidence marked by thick seams of ancient vegetation, the deposition of thick beds of strata one above another, the conversion of the vegetation into coal, the shifting of the strata and their re-elevation into high hills, all this leaves him utterly inadequate to form a conception of the lapse of time occupied in their elaboration. Prof. Phillips in his "Life on the Earth," on the supposition of the amount of sedimentary matter laid down at the mouth of great rivers, such as the Ganges, calculates that the time required for the production of the South Wales coalfield would be about half a million of years.

Mr. Hull calculates that the formation of this Coalfield would have occupied 640,000 years, but the higher estimates given by Sir C. Lyell,* appear to me to be the more probable approximation when we consider the multiplicity of the phenomena involved in its history.

BOTANY OF COAL—CHEMISTRY OF COAL, ETC.



Pecopteris lonchitidis, Sternberg.

We have not long been acquainted with the fact that Coal is of vegetable origin, however surprising it may appear that men

* Lyell's Elements of Geology, pp. 386—7.

could have worked for so many years among the impressions of fern leaves and other plants which are brought up in thousands among the debris of every shaft, without suspecting the history of the structure of coal. For centuries it was believed to be of mineralogical rather than of vegetable origin. The earliest record with which I am acquainted of any Coal-plant in a fossil state, is in Queen Elizabeth's time, by Camden, who mentions having seen some impressions which had the appearance of oak leaves, near the town of Cærwys, in Flintshire; yet even as late as 1812 we find the impressions of plants upon the coal shales spoken of as "mock plants or resemblances," and "mineral sorts of foliage," after the fashion of "Omphalos." Now it is accepted as a simple matter of fact that all coal is of vegetable origin, as demonstrated not only by the masses of plant remains with which it is surrounded, but by its microscopic structure and combustible properties.

Two things, however, strike the botanist with regard to the luxuriant vegetation which flourished in the Palæozoic coal period; first, the peculiarity in structure of the trees and plants of that epoch, differing greatly in many respects from any forms now living; and secondly, the uniformity in that vegetation which ranged from the Arctic regions of Spitzbergen to the 30th parallel of latitude. In many instances the plants of the Coal are supposed to belong to groups and families differing altogether from existing forms, but of the plants most commonly preserved, the Ferns which form a large proportion of the Carboniferous flora are evidently allied to our modern species. The most abundant are Pecopteris, of which more than 60 species are determined, Sphenopteris, and Neuropteris. Of Pecopteris, the young fern leaves coiled up ready to unfold with the return of spring have been found, and specimens have been obtained with the marks of the sori, or seed vessels, on the backs of the leaves. No less than 130 species of fossil ferns are known from the British coal strata, many of them being allied to the tree ferns of New Zealand and the Indian Archipelago.

CALAMITES.

The common Horsetail of our ponds and swampy marshes is a recent ally and example of two fossil genera of plants of the coal, Calamites and Equisitites. Dr. Williamson believes that the Calamites grew to the size of great trees, attaining a height of more than 20 feet, with a fistular pith, exogenous woody stem, and a thick bark which has been turned into coal, leaving only the cast of the pith. They show no leaves attached, but the plants known to collectors as Annularia and Sphenophyllum, are believed by Prof. Carruthers to be the leaves of Calamites.

SIGILLARIA AND STIGMARIA.

The Sigillaria was a great tree of the Carboniferous period, and twenty-eight species are enumerated as British. Stigmaria has been clearly demonstrated by Mr. Binney to be the root-stalks, radiating outwards and spreading horizontally; and in the Manchester Museum is the stem of a large Sigillaria passing downwards into massive rootlets, or the Stigmaria ficoides of former collectors. Dr. Hooker believes that the Sigillaria were large Cryptogams, but very highly developed; and Mr. Carruthers ranks them with the club mosses (Lycopodiaceæ). Sir C. Lyell mentions a Sigillaria found at Newcastle, 72 feet in length; and Hugh Miller, when visiting the Wolverhampton coalfield, saw seventy-three stumps of these trees in three tiers, one above another, packed in such a way as to convince him that three successive forests grew on the same site.* It was within the hollow cylinders of some Sigillariæ, in Nova Scotia, that Prof. Dawson and Sir C. Lyell found the remains of the skeleton of a land Reptile, the first ever detected in carboniferous strata. In the same hollow cylinders were also found numerous land snail shells, and some millepedes or myriapods. Since that Dr. Dawson has discovered nine skeletons of reptiles belonging to four species, all preserved in hollow carboniferous trees.

* "First Impressions of England," &c., p. 233.

LYCOPODIACEÆ.

Lepidodendron. The Lepidodendra are abundant and large-sized plants of the British Coal measures, and they bore sporangia and spores similar to those of existing club mosses. Conical-shaped fruit cones known as Lepidostrobi have been found in the trunks of Lepidodendron, and it was the opinion of M. Brongniart, that the Lepidostrobi were the fruit of the tree itself. This has been confirmed by finding specimens in Coalbrook Dale with the fruit attached to the branch. Lepidodendra differ from Sigillaria in the arrangement of the leaf scars which are diamond shaped. The fossils known as Knorria have been determined by Mr. Carruthers to be the roots of the Lepidodendron. This great coal-tree has been found 49 feet long in the Newcastle collieries.

CONIFERÆ.

The Conifers, or the Fir Tribe, take a high position in the ranks of vegetable organisation, and the fact that coniferous trees were abundant when the Palæozoic coal plants grew, overthrows the idea that the Carboniferous flora was altogether made up of cryptogams, and plants of low organisation. The Coniferous trees of the Palæozoic period are referred to the Pine genera, but they differ, as a rule, from the more modern spruce, larch, juniper, cypress, and yew, and are more nearly allied to the Norfolk Island Pine, a species of Araucaria, now confined to a very small area of our globe. The pith, too, in the old Pine trees of the coal period was of large size, whereas living firs have no pith. The fossil known to collectors as Sternbergia has been shown by Prof. Williamson of Manchester to be the pith of coniferous coal trees. Dr. Hooker also has determined that the fossil fruit known as Trigonocarpum is the fruit of a coniferous tree, which like the fruit of the yew was enclosed in a pulpy envelope. Such is the fruit of the Japanese tree Salisburia, occasionally seen on lawns in England, and of which there is a fine specimen at Kew. Heart-shaped leaves like those of the living Salisburia, or the Stricklandinia of the

Oolites, occasionally occur in the coal measures, and these are probably the leaves of coniferous trees. The Nœggerathia of the cabinets of collectors is believed to be a coniferous leaf.

The Antholithes of Lindley are considered by Mr. Carruthers to belong to a tribe of plants which grew parasitically on the trees of the coal forests, and to be allied to the Broom rapes (Orobanche). Dr. Hooker believes that the present vegetation of New Zealand with its tree ferns, its club mosses, and its great variety of conifers, makes the nearest probable approach of any existing vegetation, to that wonderful plant-growing period which produced our coal.

Many writers have attempted to give us imaginary pictures of a dark and dank though luxuriant vegetation, supposed to grow in a steamy atmosphere without a bird to sing from the branches, or an insect to flit among the leaves; without a flower or fruit, a dense sombre forest without beauty, and almost without life. I doubt the correctness of these conclusions, and expect that we possess but a very fragmentary knowledge of the plant or animal life of the Coal period, although it is very probable that both were in a less highly developed state than the flora and fauna of modern days. Be this as it may, millions upon millions of tons of carbon, the remains of millions of trees and plants, are fixed in solid masses in the crust of the planet, stored up for the benefit, as far as we can divine, of no being in the wide world save one, and that is Man.

CHEMISTRY OF COAL.

The Chemist learns from investigation that Coal is the result of the chemical transformation of vegetable matter which existed myriads of ages ago, and which, for myriads of ages, was locked up in the recesses of the earth to come forth as the most valuable of all Nature's treasures to the Human race. The ancient Coal plants, as with those which now exist, derived their nourishment from the elements contained in the air, water, and soil. All plants are composed of carbon, hydrogen, and oxygen, with a certain amount of nitrogen, which they separate and combine in their seeds, sap, wood,

fibre, and leaves ; they derive their carbon from the atmosphere; water is the source which furnishes them with their hydrogen. Thus sunshine and heat, soil, air, and water, were as necessary to the Sigillariæ and Lepidodendra, as they now are to our oaks and elms, for it is through the heat and light of the Sun that the plant is enabled to store up heat and light for vegetable life and existence. It is the light and heat of the Palæozoic coal period which was stored and hidden away, first in millions of Carboniferous trees and plants, and afterwards in Coal mines where they underwent chemical transformation, which are now again evolved as light and heat in the fires of our hearths and the brightness of our gas. Stephenson used to say when he saw a steam-engine rushing on at the rate of a mile in a minute, "There goes the bottled sunshine," and it was the influence of the sunshine and heat of the Carboniferous period that converted the carbonic acid and water of that period into that marvellous vegetation which was afterwards to be secreted and stored up, through the action of a series of geological phenomena brought to bear upon that storing, which no physical geologist who has entered into the history is likely to attribute to any cause but premeditated and intelligent Design.

"There is no end," says Mr. Binney, "to the combinations, solid, liquid, and gaseous, which belong to the chemistry of coal." And so it will appear if we examine some of its products. First there is Coal gas, which alone would require a chapter to itself if dealt with at any length. It was first discovered in about 1700, by an amateur in science, the Rev. Mr. Clayton, a country clergyman in Yorkshire, who filled bladders with Coal gas, and on penetrating the bladders and applying a light to the hole, found that the air escaped in a bright flame.* The use of gas was first introduced at Redruth in Cornwall, in 1792, by Mr. Murdoch, an engineer, who lighted his own house with it. In 1797 he published his plans for gas-works, and in the following year erected an apparatus, with which he lighted the Soho Foundry

* His discovery is published in the Transactions of the Royal Society.

at Birmingham. In 1809 the first gas company was formed in London, and it is estimated that the quantity of coal now used to supply London with gas amounts annually to about six hundred thousand tons. In distilling gas from coal there are several residuary products, which have been utilized in a wonderful manner by our chemists.

Coal Tar has been made to yield by distillation, tar and coal naphtha, from the constituents of which are obtained Parafine, Creasote, and Aniline. Parafine, when purified by other chemicals, yields beautiful candles, and aniline furnishes the celebrated dyes, known as "Mauve," "Magenta," "Solferino," &c.; while Prof. Hoffman has succeeded in producing some deliciously scented ethers from coal naphtha and benzole.

Clay iron stone abounds in the coal shales and forms nodules round plants or other organic remains. These often occur in bands, and the iron they contain was probably derived from the decomposing vegetable matter of the coal measures, as we know that a good deal of iron is now segregated by trees and plants. With this brief sketch of the nature of Coal, its origin and its products, we will pass on to the consideration of the Coal-fields of the Silurian and other districts under review.

COAL-FIELDS OF NORTH WALES, ANGLESEA.

When travelling in Anglesea, from the Watering place near Amlwch to the Menai Bridge, we cross the melancholy and dreary marsh, known as Maldraeth Marsh, and behold some desolate-looking collieries. Maldraeth was supposed, by the learned antiquary, the Rev. Henry Rowlands, to have been formed by the deluge, and such is the opinion of the inhabitants at the present time. This little outlying coal-field in Anglesea presents, however, a remarkable geological phenomenon, inasmuch as its preservation is due to a great fault which has thrown down the Carboniferous rocks and protected them from denudation. Prof. Ramsay determined the succession of these strata, and it seems that, at the base of the Coal measures, the Carboniferous limestone rests on highly contorted old schists, either of Laurentian or Cambrian age.

The Millstone grit is not absent, but supports the coal measures, as in other parts of North Wales. The Coal measures which are worked at Berw Colliery are overlaid towards the north by Permian rocks.

FLINTSHIRE COAL FIELD.

The Coal measures of Anglesea are separated from the Flintshire coal-field by a hilly tract of mountain lands nearly 50 miles in breadth, and the Flintshire coal measures again, are separated from the Denbighshire coal-field by the elevation of the Mountain Limestone and Millstone grit between Gresford and Hope.

Flint, the county town, has been ruined in importance, owing to the silting up of the estuary by the river Dee; but we prefer it infinitely to Mold as a starting point for geological and archæological investigations. The Coal-measures may be traced extending along the western shore of the Dee estuary to Ari lighthouse, and the walk from Flint across the millstone grit to the Mountain Limestone west of Holywell offers excellent geology.

Near Holywell station, but about two miles from the town itself, are the ruins of the famous Basingwerk Abbey, founded, according to Dugdale, by Ranulph, Earl of Chester, A.D. 1131; but from some old Welsh charters it is supposed that the original founder was one of the Princes of Wales. The remains of the Castle are yet visible at a short distance from the Abbey. It was at Basingwerk that the Welsh chieftain, Owain Gwynedd, was encamped when Henry II. and his army were defeated at Coleshill. The Welsh allowed the king to penetrate as far as the difficult country about the Forest of Coleshill when they attacked him in a narrow defile. The slaughter was prodigious; the standard-bearer ran away, and ended in becoming "a shorn monk in Reading Abbey;" and Henry himself narrowly escaped with his life. Wolves appear to have lingered in these parts of Wales up to the time of Giraldus, for he says that the corpse of a young Welshman who fell in this battle of "*Coleshulle*," was saved from becoming

the prey of wolves and other wild animals by the guardianship of his dog. Thus the name of "Coleshulle," or hill of coal, was already known in those days! Giraldus, when travelling through the country some years after the battle, speaks of proceeding by a long and tremendous journey, and of experiencing great trepidation by being obliged to pass the pathless deserts through the dense and darksome woods where Henry "suffered for his rash presumption."

The walk between Flint and Halkin repays us by the scenery of the estuary of the Dee, and of the opposite coast. Halkin mountain is a rich mining district with the lead works of Pen-y-bryn and Henblas. The general dip of the Coal-measures is towards the north-east, and they dip under the Triassic rocks of Cheshire, which in all probability will be penetrated at some future time in search of these underlying coal beds. The Flintshire coal strata are faulted through the Cheshire Trias at a place called Parkgate, opposite Flint, between Neston and Birkenhead. This coal-field is much traversed by faults and the beds considerably upheaved by dislocations. Near Hope the lower coal-measures with fossils are faulted to the surface, and are unconformably overlaid by Permian sandstones.

The Denbighshire Coal-field may be seen from Wrexham, to the north of which place there is a section exposed along the banks of the river Alyn, west of Gresford. It is separated north of the valley of the Alyn from the Flintshire coal-measures by the great fault which has been traced by the Geological Surveyors from the coast of Merionethshire, through Bala Lake, into Cheshire.* There are a great number of iron furnaces in the neighbourhood of Wrexham, and the district of Minera, about five miles distant, displays the outcrop of the coal-measures in the immediate vicinity of lime and slate quarries. The remains of fossil fish have frequently been found in this coal-field, and among them Rhizodus, Cœlacanthus, and others described by Sir Philip Egerton. The coal-field extends southwards three miles beyond Oswestry.

* See Maps, Geol. Survey, Sheet 74, N.E. and N.W.

An expedition should be made from Wrexham to Holt and Overton on the Dee. Holt Castle was built of New Red Sandstone quarried near. This fortress, of which there are now but few traces, was erected by Earl Warren in the reign of Edward I. Norden saw it in 1620,* at which time it was still entire. It was of a pentangular shape with a bastion tower at each angle, four of which were circular, and the one facing the river square. The entrance was by a drawbridge over a deep moat, and over the gateway was a square tower. Churchyard says that,—

> "The seat is fine and trimly built about
> With lodgings fayre and goodly roumes throughout,
> Strong vaults and caves, and many an old device."

Two miles to the north of Overton, close to the river Dee, is the Church of Bangor Iscoed, near which once stood one of the largest and most ancient monasteries in Great Britain. Not a vestige, however, of the building now remains, although at various times human bones and stone coffin-lids with ancient carvings have been ploughed up. It is said to have been founded by Lucius, son of Coel, first King of Britain, A.D. 180. In 603 the monks of Bangor Iscoed numbered 1200, and when Ethelfrid, King of Northumberland, attacked the Welsh forces under the King of Powysland, they were engaged in praying for the success of their countrymen, and notwithstanding that they fought only with prayers, the Northumbrian king destroyed them wholesale and levelled their monastery to the earth. William of Malmesbury, writing in the reign of Stephen, says of this edifice, "there remained only some relics of its ancient magnificence." Leland, describing its site many centuries later, notes a circumstance interesting to the geologist, viz., that the river that used to flow on one side of its walls had, in his time, changed its bed and made a new channel for its waters, running through the middle of the monastic site.

Mr. Hull says that the Coal-fields of Shrewsbury, the

* MSS., Harleian, in British Museum, and vol. i. Pennant's Tours.

Clee Hills, and the Forest of Wyre, are of so valueless a nature as regards their coal deposits, that he does not consider it necessary to attempt an estimate of their resources.* I shall, therefore, content myself with drawing attention to a few of the Geological phenomena of these districts.

SHREWSBURY COAL-FIELD.

Here the Coal-measures extend in a narrow strip from the base of Haughmond Hill, four miles east of Shrewsbury, to Allerbury on the banks of the Severn, a distance of nearly twenty miles. Haughmond Hill is a mass of Cambrian rocks, which rises through the surrounding district of New Red Sandstone, Carboniferous and Permian Strata.

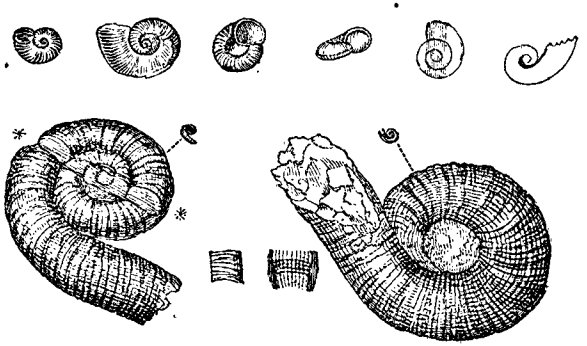
At Haughmond the coal strata repose on Cambrian rocks, and to the westward on Silurian rocks, without the intercalation of either Carboniferous limestone or Millstone grit. Sir Roderick Murchison directed attention,† years ago, to the manner in which certain cavities of the rocks of Haughmond, and also at Pitchford, east of Shrewsbury, are filled with bitumen and mineral pitch. This bitumen occurs in fissures, and a large dyke of Trap rock penetrates through the Cambrian strata of the hill on the "Warren." It was the impression of myself and other geologists, when closely examining the phenomena of this exudation of mineral pitch, that the bituminous matter may have been derived from the carbonaceous deposits which once probably overlaid the Cambrian rocks, and may have exuded from them into the interstices of the older deposits before their upheaval into mountain ridges, especially as the bituminous matter occurs most abundantly where Trap rocks appear at the surface, and the Cambrian masses are fissured.

The Coal-measures in the neighbourhood of Shrewsbury, furnish a band of limestone in the upper strata, containing a peculiar collection of fossils. Among them are a number of minute crustaceans,—the Estheriæ of Professor Rupert Jones

* Coal-fields of Great Britain, p. 92. † Silurian System, p. 266.

(Leperditia inflata, Siluria), a bivalve shell (Anthracosia), and a marine shell (Spirorbis). But the remarkable history attached to this limestone is that mentioned by Mr. Hull, viz., its persistency with the *uppermost coal strata* over an area of 10,000 square miles, as it can be traced in the upper coal-measures of Coalbrook Dale, Lancashire, Warwickshire, and in the Forest of Wyre in Worcestershire.

UPPERMOST LIMESTONE OF THE COAL-MEASURES.



Microconchus (or Spirorbis) carbonarius, Sil. Syst. The real size is given in the minutest of these figures, whilst the upper figures are somewhat magnified, and the lower very greatly so. * * The mark of attachment to some small cylindrical body.

Haughmond Abbey was situated on the edge of a once extensive chace or forest. It was founded in the last year of the reign of William Rufus, and the ruins, though small, are picturesque. The portions best preserved are a fine doorway and the chapter house. Leland says that a hermitage and chapel stood here before the building of the Abbey. Near the ruins is Battlefield, the scene of the memorable battle of Shrewsbury, and the legend goes that close by Lord Douglas was taken prisoner. In a plot near the churchyard is a mound where the numerous slain are said to have been buried, and a field called the King's Croft is supposed to have been the head-quarters of Henry IV., while Percy lay at Shrewsbury.

COAL-MEASURES OF THE CLEE HILLS.

The Clee Hills have already been referred to as being the remnants and outliers of great formations, which once undoubtedly spread far and wide, continuously, from the Coal-fields of South Wales and the Forest of Dean, over the plains of Herefordshire to the Titterstone and Brown Clee Hills of Shropshire. Encircled on all sides by the Old Red Sandstone and its fossil fishes, these outlying coal measures, capped by an overflow of hard basalt known as Dhu Stone, rise to a height of nearly 1800 feet above the sea, and it is to the basalt, and the resistance it offers to the denuding forces, that, in all probability, the Clee Hill coal deposits owe their preservation. The igneous masses of basalt were poured forth as liquid lava after the formation of the lower coal-measures; they may be seen at "The Giant's Chair" standing out in rude columns. The shafts of the collieries were drove through the basalt before quarrying the coal. A great fault cuts off the coal-measures of Cornbrook on the south-east from those of Hoar Edge and Horse Ditch on the north-west. The Millstone grit, too, on "The Common," is thrown down into a valley, and the underlying Old Red is faulted against it like a cliff upheaved.

COAL-MEASURES OF THE FOREST OF WYRE, WORCESTERSHIRE.

Although this Coal-field is nearly as large in superficial area as that of the Forest of Dean, its products have never proved of much mineral value. It extends from the north end of the Silurian ridge of the Abberley Hills to a little south of Bridgenorth, its principal expanse being the Forest of Wyre. The forest trees of Wyre were cut down before the days of Drayton, who says:—

> "When soone the goodly Wyre, that wonted was so hie
> Her stately top to reare, ashamed to behold
> Her straight and goodlie woods unto the furnace sold."

Still it is for England a fine stretch of woodland, and is always connected with pleasant memories to the geologist,

botanist, and naturalist. I had the pleasure more than once of going over this district in company, and under the guidance of the late Mr. George Roberts, formerly clerk to the Geological Society, who knew it thoroughly, and who has given an account of its mineral and fossil contents in a work known as "The Rocks of Worcestershire."

The strata of which this Coal-field is composed, consists merely of the *Upper Coal-measures*, and along the western edge Mr. Roberts found in them the fossiliferous band alluded to as extending into Lancashire and Yorkshire, and containing Spirorbis, Estheriæ, &c. Entering the forest from Bewdley, the explorer may walk to Dowles, following the Dowles brook in its course through the woods. At the Hill Farm on the eastern bank of the river, and at the Town Mills, there are expositions of Coal-measure shales and sandstones, crowded with the impressions of ferns. Here, were obtained some specimens of Pecopteris, and other ferns, retaining their sori or spores of fructification. These Coal-measure shales and sandstones cross the Severn at Dowles Point, where there is a quarry with remains of Stigmaria and Calamites. At Arley Colliery, near Bewdley, the coal-measures were sunk through the depth of 450 yards, and then a basaltic rock was reached similar to that which has come to the surface at Shatterford. The banks of the Severn from Bewdley to Upper Arley, afford good sections, particularly on the right bank below Cliff Wood.

At Shatterford, about five miles from Kidderminster, the Basalt has elevated the Coal to the surface, and alters and roasts the shales. At a place known as Belman's Cross, excellent examples of metamorphism are exhibited, and I have seen impressions of plants in the metamorphosed shales. At Coleridge Wood the basalt is quarried for road stone, and forms in one place quite a rock pinnacle which commands a fine view of the surrounding country. The coal-measures are also well seen at Blakmoor, and Gib House pits, from which places Mr. Roberts obtained some remains of Carboniferous fishes.

Wyre Forest offers one of the best localities in this part of England for botanical researches, and many a good plant have I seen when rambling there with our Worcestershire botanist, Mr. Edwin Lees. Here grows the reindeer lichen, side by side with the ling, and it probably has grown there ever since the time when the reindeer, and perhaps the mammoth wandered thousands of years ago through the woods. The Alpine Club moss (Lycopodium alpinum) was once gathered here by Mr. Babington, and a specimen of another plant is still in the possession of a lady at Stourport.* Both in Wyre Forest and on Hartlebury Common relics of an alpine and sub-alpine flora are occasionally found on forest, unbroken ground, where still linger a few relics of that alpine vegetation, which in the days of the reindeer, the mammoth, and the tichorine rhinoceros, we may well believe grew generally over this part of Great Britain.

COAL-FIELD OF COALBROOK DALE.

This Coal-field is so well known, having been the subject of an elaborate memoir by that distinguished geologist, Mr. Prestwich,† that I consider it unnecessary to do more than refer to the fact that Silurian rocks form the general foundation of the Carboniferous deposits in this district. The coal-measures have furnished many fine fish remains, among them are Hybodus, Gyracanthus, Cochliodus, and Megalichthys, while I have before me as I write, the cast of a large reptile (Labyrinthodon) presented to me by Mr. George Maw, the original of which was found in the Coalbrook Dale coal-measures. Eophrynus Prestwicii (Woodward) from these rocks is the oldest known spider.

FOREST OF DEAN COAL-FIELD.

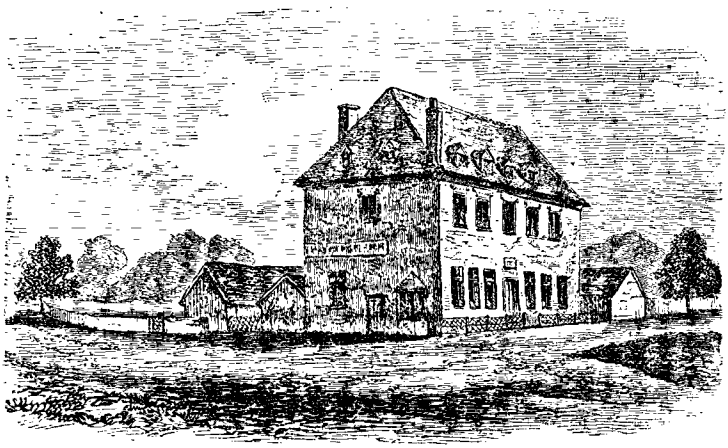
This is an undoubted outlier of the Coal-field of South Wales, which it resembles in every particular in geological structure.

The Forest district is separated from the rest of the county

* Lee's Pictures of Nature, p. 265.

† Geol. Transactions, vol. v., 2nd series.

of Gloucester by the river Severn, which runs along the line of a fault which has elevated the forest on the one side, and thrown down the district around Bristol on the other. The Royal Forest is an area of 29,000 acres, about half of which is covered by woodland. Its oaks were so renowned in



SPEECH HOUSE, DEAN FOREST.

the time of Queen Elizabeth, that an ambassador was purposely sent from Spain by Philip the Bloody, to procure its destruction either by negociation or treachery. Even now the magnificent beech trees in the neighbourhood of the Speech House are well worth a visit. William the Conqueror was hunting in the Forest of Dean when he received the news of the burning of York by the Northumbrians; and then and there swore "By the splendour of the Almighty," that he would utterly exterminate that people. A havoc more diabolical was never perpetrated, for William of Malmesbury, writing about eighty years afterwards, says, "From Yorke to Durham not an inhabited village remained. Fire, slaughter, and desolation made a vast wilderness there, which continues to this day."

The Coal-measures are surrounded by belts of Millstone grit and Carboniferous limestone which dip into the coal-field on all sides, forming a regular basin of which the Old Red Sandstone is the basement rock. The scenery is very beautiful. From the edges of this basin westward rise the Welsh Hills, the Vans of Brecon, and Pen-Cerrig Calch, rocks there elevated to the height of nearly 3000 feet, being the equivalents of those upon which the geologist stands when rambling along the ridges of the Forest of Dean. On the westward too are the great escarpments which form the limestone gorges of the Wye, with their weird caves full of the bones of the extinct Mammalia, and the vestiges of Human races that have long ceased to exist. On the east are the bold elevations of the Cotswold range, the rich vale of Berkeley and the Severn, often in its lower reaches studded with sails and flowing through rich pastures and peaceful villages; while on the south is the estuary of the Severn, and the Mendip Hills.

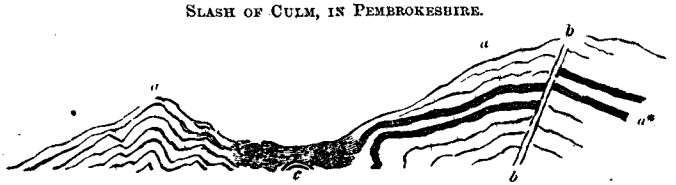
The Area of this Coal-field is about thirty-five square miles and the Coal-measures contain thirty coal seams. Some years ago I gave a good deal of attention to the geology of this coal-field, and examined all the coal seams wherever they presented themselves *in situ*, and the position of the coal-measure sandstones. The Bottom coal, as at Ruspitch, is only about a foot in thickness, and is then overlaid by nearly eighty feet of greenish-coloured sandstone full of the remains of coal plants. In one of the coal seams called the Coleford High Delph is an *old river-bed* filled with sand, clay and pebbles. It is known by the local name of "The Horse," but is different from the "horses" of the northern coal-fields which are merely faulted rock masses, or trap dykes, and not old river channels. Towards the westward margin of the coal basin between the Speech House and Lydbrook, the coals are being worked on their outcrop; and the pits are entered by horizontal tunnels. The Coal-measures are wretched botanising ground and famous principally for *Nettles*. The poorer miners still use nettles as an ingredient in spring salads and for nettle broth.

"Of Nettels lykwyse there be store
In sallets at this season,
For men be nettled more and more
With palltryse passynge reason." *

THE SOUTH WALES COAL-FIELD.

This Coal-field is the most important in Great Britain, as it has been ascertained to present a thickness of strata amounting to more than 10,000 feet. The greatest length of the South Wales coal basin is from east to west extending from Pontypool to Kidwelly, a distance of about sixty miles, while its greatest breadth, from Hirwain to near Cardiff, is about twenty miles. The Pembrokeshire coal-field extends from Tenby to St. Bride's bay, a distance of eighteen miles. The South Wales coal-field is bounded on the south next the Severn estuary by Old Red Sandstone, Mountain Limestone, and Millstone grit, on which rest unconformably Triassic and

SLASH OF CULM, IN PEMBROKESHIRE.



a, Contorted Culm strata, with Stone-coal, *a**. *b*, Fault. *c*, "Slash" f finely triturated Culm between violently contorted strata, and probably upon a great line of fracture.

Liassic rocks, while to the north, east, and west an almost uniform belt of Millstone grit and Mountain Limestone supports the Coal-measures and rests on the Old Red Sandstone. Crossing to Pembrokeshire over Caermarthen Bay, the coal seams become *anthracitic*, and lose their bituminous qualities, which may be owing to the numerous Trap rocks which in Pembrokeshire run from east to west along the strike of the Coal-measures. As the Pembrokeshire coal-measures are very inferior to those of the South Wales coal-field in scenery, in

* MSS. (Lenten Stuff) in Ashmolean Museum.

exposition at the surface, and in works by means of galleries; I shall pass them by.

For the study of the physical geology of the Coal-measures I consider no district can compare with the beautiful hills and vales of Monmouthshire and Glamorganshire. The country is, as a rule, subdivided into a number of narrow valleys which run from the encircling belt of Mountain Limestone towards the sea, they are separated by long rounded or tabulated hills which thus impart a mountainous character to the general scenery. The best route to take for examining the physical geology and scenery of a portion of this coal-field, is to start from Abergavenny on the Old Red Sandstone in the vale of Usk. Ascending from the Lower Old Red with its wooded hills of cornstone, and leaving behind the Sugar Loaf, and Skyrrid, capped with Old Red Conglomerate, the summit of the Blorenge Mountain forms the corner of the line of the great escarpment of Mountain Limestone which dips under the coal-measures of Blaenavon. Passing from the vale of Usk by the limestone gorge of the Clydach, the junction of the Millstone grit may be seen at Trefil. The Millstone grit occupies a large area of table land; and the pleasantest walk is up the bed of the Clydach stream past several waterfalls, and where occasional sections crop out. The fossils of the Lower Coal-measures were thoroughly worked out by Dr. Bevan, to whose guidance I have been much indebted on several occasions, in enabling myself and friends to understand the correlation of the coal-measure rocks in this part of the basin. Brynmawr is an ugly mining town not much resembling picturesque Abergavenny, and the other old Welsh towns of the vale. It is, however, built at the head of one of the mountain upland valleys of the district, and at the outcrop of the coal-measures, while considerable hills, composed of greenish Pennant sandstones, which overlie the Lower Coal-measures, rise all around. Seams of coal occur in the Pennant series, but they are comparatively poor, so the principal bearing strata in the South Wales coal-field are the Lower Coal-measures which underlie the Pennant sandstones; and the

Mynydd Isslyn series of coal-measures, which rest upon the Pennant rocks.

In the South Wales coal-field much of the coal is obtained by "working a level" along a vein of coal occupying a certain position in a hill, and in some places the underground excavations extend for miles. "Patch working" is nothing more than quarrying coal in the open air, and I had the pleasure of watching this process, in company with Dr. Bevan, at a place called the Elled Patch between Nantyglo and Beaufort. We actually stood upon a floor of coal and saw the seams of coal interstratified with sandstones, shale, and ironstone, and we hammered out beautiful impressions of ferns from the overlying clays. Some Sigillariæ were standing erect, and Dr. Bevan obtained about sixty species of coal plants from these open Elled quarries. One bed of shale at the base of these deposits was very rich in the remains of fish belonging to Holoptychius, Cælacanthus, and Ctenacanthus. Some thin coal seams were found in the Millstone grit abounding in *marine fossil remains*, including Productus, Bellerophon, and Goniatites. In some *higher beds*, in mines of the valley of the Ebbw, Dr. Bevan found Anthracosia and Spirorbis; so the Lowest Coal-measures appear to form the upper limit of the marine fauna, such as Goniatites, Spirifers, Bellerophons, &c. The segregation of iron in nodules, interstratified with coal, is a very important feature in the Carboniferous deposits, and in the remarkable section first alluded to near Beaufort. Coal seams were seen resting with ironstone nodules lying above and below them. The iron in this instance was segregated with clay around the leaves and stems of fossil plants, while some nodules were segregated round a fish-tooth, or shell. Merthyr Tydvil, where are the great Ironworks of Mr. Robert Crawshay; and Taff Vale, near Cardiff, are both famous localities for these ironstone nodules. There is some interesting geological ground near Cyfartha Castle, Merthyr, up the little river; and sections may be traced by going up, along its banks, towards the hills on the north-east.

PENNANT GRIT SERIES.

Above these Lower Coal-measures are the *Middle Coal* seams of Glamorganshire and the Pennant rock of Monmouthshire. In Monmouthshire this rock is comparatively unproductive, whereas in Glamorganshire it contains coal seams 3000 feet in thickness. Within the escarpments formed by these Pennant coal-measure sandstones, which rise in some places to the height of 1000 feet, lie the higher and Upper Coal-measures of the great table-land of Glamorganshire, known as the Pellengare and Isslyn series. The Pennant grit has much to do with the formation of the physical features of the country, and it is impossible to ramble over the tops of the hills crowned with this hard rock without observing how it has resisted the denuding forces which have hollowed out the softer strata.

At Pontypool this rock is about 1000 feet thick, and over it lies the great Mynydd Isslwyn seam, the only upper coal-measure seam east of the Taff. It principally supplies Newport and Cardiff with coal, and furnishes also Anthracosiæ, and fish remains. It is somewhat singular that ironstone was smelted at Pontypool in 1560 by charcoal from the forests of the neighbouring hills before the discovery of coal in these regions. The largest faults in the South Wales coal-field are in the north-eastern part of Glamorganshire, and one runs from Merthyr to Llancaiach, where the Mynydd Isslwyn vein, which is worked by a level at a place called Tophill, is worked, at the colliery, only a few hundred yards south of the fault, by a deep pit. The scenery of the Sirhowy and Rhymney valleys is wild and peculiar, with collieries dotting the high grounds between the valleys. Above Rhymney Gate, cropping out along the river-bed, is the band full of marine shells, already described as close on the horizon of the Millstone grit.

At Llantrissant in Glamorganshire, there are hæmatite iron ores, believed to be of Permian age; and at Llanharry, three miles to the south, remains of Roman pottery have been found where that people worked a bed of ore long ago. The Coal-beds at

Llantrissant have been much disturbed, but they are referred to the Middle Coal-measures of the South Wales basin, and from them Mr. John Edward Lee, obtained portions of the skeleton of an air-breathing vertebrate allied to the modern batrachians, and which is described by Prof. Owen as belonging "to that low, probably primitive, air-breathing type, which with developmental conditions of the bones, like those in some fishes, and very common in Devonian fishes, showed forms of the skeleton more resembling those in saurian reptiles than one attained by any of the more specialised batrachian air-breathers of the present day." *

The Llanelly coals belong to the uppermost series, being higher than the Penllengare seams. Perhaps the best place to see the *Upper Coal-measures* is in the neighbourhood of Neath, distant about eight miles from Swansea. The geology should be examined between Bishopston on the south near Swansea, to Llandibie on the north; and again between Neath and Cwm Trwch, in Breconshire (near Ystradgynlas) where the coal is anthracitic. Mr. Hull believes that the cause of the change of the bituminous coal seams of the southern and eastern divisions of the Welsh coal-field, into the anthracitic coal seams of the western area, is owing to the fact that the strata of the western side have been exposed to a higher degree of internal heat than those of the eastern, and have thus become altered into anthracite.

Neath Abbey must have been a splendid edifice, although no adequate idea can now be formed of its original magnificence. Leland describes it as "the fairest abbey in all Wales." It was founded by Richard de Granvil, younger brother of Robert Fitz Hamon, on returning from the Holy Land in 1111, when he brought with him an eminent architect, Lalys, who also built Margam Abbey. The first abbot died in 1145. The monks were Cistercians, and in the Annales de Margam, Morgan ap Owen a Welsh chieftain is said to have burnt the monastery, and killed one of the holy brethren. Edward II. and D'Espenser took refuge at Neath after their

* Geol. Mag., vol. ii., p. 8.

flight from Caerphilly, and were afterwards betrayed by a monk into the hands of the enemy at Llantrissant, when D'Espenser found his doom at Hereford, and the king at Berkeley.

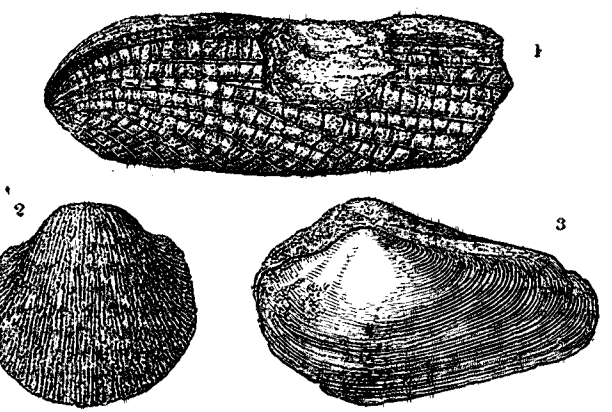
It is only by following up good sections that the geologist can possibly comprehend how at the close of the Carboniferous period, so large an area of Wales and Siluria must have been covered by continuous sheets of coal-measures, and can realise the enormous destruction of rocks that has taken place, leaving only the mere fragments of the strata which once spread far and wide; how the Pembrokeshire coal-field must formerly have joined that of the South Wales field, which again must have been continuous with the coal-field of the Forest of Dean, and with that of the Clee Hills and Shropshire. There is a remnant of Carboniferous limestone near Corwen in North Wales, which shows that a fragment only remains of this great Carboniferous formation of South Wales, which, in all probability, once spread over the greater part of North Wales, and of which the Denbighshire and Flintshire coal seams are the wrecks. This may seem astonishing until we remember that the North American coal-fields from the Appalachian basin to Texas, cover 200,000 square miles; and that it is not impossible that the British area of coal-measures which now occupies only about 5,500 square miles, may have been previous to its denudation, as extensive as the American.

ORGANIC REMAINS OF THE COAL.

Besides the evidence of the former existence of immense Forests of trees and plants during the Coal period, we find proofs of the existence of Batrachians, and lizard-like Reptiles of several species. Besides these, Land-shells allied to our Pupas and Helix have been found in America; and Insects representing our myriapods, spiders, and dragon-flies. The wing of a dragon-fly found in coal shales in America, measured seven inches from tip to tip of the expanded wings; and although fossil insects are scarce in England, the Spider from Coalbrook Dale, already alluded to, is larger than any

known European species. Few remains of reptiles and insects have as yet been discovered in the Carboniferous rocks of Great Britain, and more especially in those within the Silurian area, although we know that the carboniferous seas supported numerous fishes, radiata, mollusca and articulata. This may be owing to the fact that some of the coal-seams are found to have been deposited under sea-water, and to be associated with strata containing marine organic remains.

INSECT AND SHELLS OF THE COAL-MEASURES.



1, Wing of *Corydalis*? Brongniarti, Mantell. 2, Productus scabriculus, Sowerby. 3, Anthracosia acuta, Sow., sp. (Formerly supposed to be allied to Unio. Silur. Syst. p. 105.)

CHAPTER XI.

PERMIAN ROCKS.

Classification of Permian Rocks—Development of—Magnesian Limestone—Fossil Remains of—Breccias—Position of—In Scotland—In Silurian District—Permian Strata of North Wales—Alberbury Breccia—Bridgenorth—Historic Records of—Drifts—Church of Quat—Outlier of Church Hill—Alveley—Quarries at—Conglomerate at Coton—Enville—Erratics in Permian Breccia—Hagley—St. Kenelm—Clent Hills—Warshill Grit—Breccias of the Abberley and Malvern Hills—Of May Hill—Organic Remains of the Permian Rocks.

THE series of Strata now termed Permian were for a long time classed as Lower Triassic from their great resemblance in colour and mineral character, to that group of Secondary rocks. It is now ascertained, through examination of their position as regards the underlying Palæozoic rocks, and the overlying Triassic strata, combined with the determination of their organic remains, that the Permian rocks constitute the *uppermost series* of the Palæozoic or Primary formations. They were described, many years ago, by Prof. Sedgwick, as regards their position, and were compared by him with German strata of contemporary age. The name Permian was given by Sir Roderick Murchison after his explorations in Russia, and is derived from an extensive region which composed the ancient kingdom of Permia, and where these strata contain numerous fossils. The principal development of British Permian strata is in the north of England, where geologists have divided them into three groups, Upper, Middle, and Lower. These divisions do not hold good as regards the North Wales and Silurian areas, where the Permian rocks are often seen clinging, as it were, to lines of fault, and where

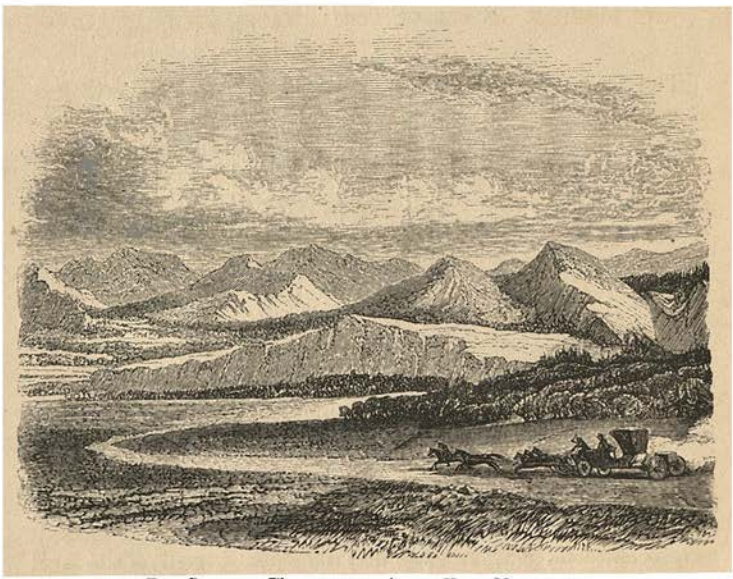
only the lower beds are exposed, the Breccias, as a rule, being uppermost. I therefore give the following table of the strata in the north :—

			ORGANIC REMAINS.
Upper Permian ...		Bunter Schiefer of Germany.	*Fish.* Palæoniscus. Pygopterus. Acanthodus. Cælacanthus. Platysomus.
Middle Permian ...	Magnesian limestone and marl slate.	Zechstein and Kupfer Schiefer.	*Mollusca.* Lingulæ. Producti. Strophalosia. Spiriferæ. Schizodus. Arca. Avicula. Camaraphoria.
			PLANTS.
Lower Permian ...		Rothliegende	Psaronius. Lepidodendron. Asterophyllites. Ferns and Walchias. Noeggerathia and Conifers.

The Upper Permians are best developed at St. Bee's Head on the coast of Cumberland.

The Middle formation is the celebrated Marl slate and Magnesian limestone of Durham and Yorkshire. It has furnished the genus of reptiles known as Protorosaurus, found also in the Kupfer Schiefer of Germany, several remains of Labyrinthodonts, numerous fossil fishes of Palæozoic type, seventy-seven mollusca, more or less allied to Carboniferous forms, and some corals also of Palæozoic type. These beds are marls and sandstones which separate the Magnesian limestone, where that rock is present, from the Coal-measures. To this series belong the Penrith Sandstone of Prof. Harkness, and the celebrated Corncockle Muir Sandstone of Annandale.

In Scotland, Breccias appear to lie at the base of the Permians, but in the Silurian region they occupy a higher position, and overlie purple sandstones with silicified plant remains. In many parts of England, the Lower Permians contain plant remains similar to those found on the continent, especially the silicified trunks of tree-ferns called Psaronius.



THE GURMAYA HILLS OF THE SOUTH URAL MOUNTAINS.

The quarry of Corncockle Muir, in Annandale, has furnished Sir William Jardine with his valuable collection of reptilian footprints.* From it have been excavated slabs bearing the fossil footprints of reptiles. So perfect are the fossil impressions of the footprints, that the regular succession of step after step can be distinguished on the quarried slabs of the bright red stones. No bones or teeth, whatsoever, have been discovered of these reptilia. Merely their footprints,

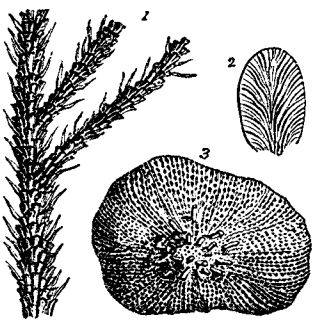
* See "Ichnology of Annandale," by Sir Wm. Jardine, Bart.

impressed as they walked over the yielding mud, have come down to us, singular records which have endured throughout a vast lapse of time, while every other trace of their existence has apparently passed away from the sandstone matrix of the rock. Jardine Hall, and some other good houses in this neighbourhood, are built of this Corncockle sandstone.

THE PERMIAN STRATA OF NORTH WALES, SILURIA, AND THE CLENTS.

The visitor to the little Coal-field of Anglesea, will recognise the Permian red marls, sandstones, and conglomerates which there overlie the coal-measures unconformably. The point the geologist should remember is, that the coal-field of Anglesea and its overlying Permian strata, are *outliers of two distinct formations*, separated by mountain tracts fifty miles in breadth from the Coalfield and Permian fringe of Flintshire on the east. One relic of a Permian outlier between these two points, was discovered some years ago by Mr. Maw. This is in the Vale of Clwyd, but here the Coal-measures were denuded before the Permian rocks were laid down, for they rest unconformably on Mountain Limestone. The Anglesea outliers should be studied in conjunction with those of the Vale of Clwyd as evidencing the enormous upheaval, dislocation, and subsequent denudation through which the Coal-measures and Permians of Anglesea have been isolated from those of Flintshire, as well as the fact that, in the Vale of Clwyd, local denudation had cleared away the coal-measures before the Permian rocks were deposited in that area. The situation where Mr. Maw discovered this Permian sandstone, is at the head of the Vale of Clwyd, near the road between Pentre Glyn, and Caer Owen, and the rock has been pierced by mining in search of hæmatite ; it intervenes between the Bunter Sandstone (Lower Trias) and the Mountain Limestone. All indicates a great erosion of Carboniferous rocks in this district before the accumulation of the Permian strata, for they are laid down on nearly horizontal Carboniferous limestone, and the upheaval and dislocation of

both formations must have taken place before the unconformable deposition of the overlying Bunter Sandstone. At Pentre Celyn Mr. Maw succeeded in obtaining some impressions of Permian plants.*



PERMIAN PLANTS AND POLYZOAN.

The next locality, as far as I know, where Permian strata may be seen *in situ*, is between Wrexham and Oswestry, where the Lower Permians, with their peculiar purple and red marls and sandstones, are ascertained to be upwards of 1000 feet thick. They flank the Coal-measures on the east unconformably, being themselves covered unconformably by the Trias or New Red Sandstone. They occur along the banks of the Dee, near Overton; and east of Wrexham. North of Wrexham, the Trias rests unconformably on the Coal-measures without the interposition of the Permians, as may be seen near Hope (some two miles from Hope station) on the Chester and Holyhead Railway. We pass over Permian rocks on the road between Oswestry and Ellesmere.

About eighteen or twenty miles from Shrewsbury, in the neighbourhood of the beautiful Breidden Hills, is Alberbury, where may be seen the famous "Alberbury breccia," described by Professor Sedgwick long ago. From Alberbury to Cardeston the breccia runs in an escarpment for nearly two miles.

* Geol. Mag., vol. ii., pp. 380—523.

It is composed of fragments of carboniferous limestone and white quartz, the relics of broken-up and re-aggregated Carboniferous and Lower Silurian rocks, for I believe that the white quartz was derived from Llandeilo strata, such as now flank the Breidden range, in which it has been segregated in fissures. Underneath the breccia are purple shales and sandstones, as at Warshill, near Kidderminster. These lower sandstone strata may be seen at the escarpment at Cardeston, and at Pecknall, west of Alberbury underlying the conglomerate, and dipping away from the coal-measures of Coed Way. A good way of following up the succession of rocks, is to go from Shrewsbury to the Middletown station on the Welshpool Railway, to ascend Middletown Hill, observing the peculiar felspathic conglomerate at its base, and then to strike for Bauseley, and cross from thence by Pecknall and Alberbury to the banks of the Severn.

When exploring the neighbourhood of the Wrekin, or Coalbrook Dale, the geologist will do well to cross over to the retired village of Lilleshall, at the northern extremity of the Coalbrook Dale basin. Very singular is here the occurrence of Trap rocks, bringing Silurian strata to the surface; and the relations between the Coal-measures and the Permian rocks, may be seen in the short distance between Lilleshall and Lilleshall House, while towards the northern edge, near Newport, all the Palæozoic series sink below the plain, and are unconformably covered up by the Trias. Here, too, stand the ruins of Lilleshall Abbey, with its decorated Norman archways, and beautiful windows of later date.

The neighbourhood of Bridgenorth is good ground for the geologist who would study faults, river drifts, erratic boulders, and the relations between the Trias and the Permian, and the Permian and Carboniferous rocks; while the town is famous for its antiquarian lore. A few words with respect to this ancient place! Bridgenorth is said to be of Saxon origin, and to have been founded by The Lady Ethelfleda, as she is called by the chroniclers, daughter of King Alfred the Great. Leland says, "the name of Bridgenorth is but of late tymes usurped," and that "in all antient records it is called Bridge Bridge."

Bishop Gibson supposes it to be the Ghatbrigge of the Saxon Chronicle, where the Danes built a castle in 896. In a charter of King John, it is called Bruges, and in another of Edward III. Bruggnorth. Speed writes that in ancient records it was called Bruge. Only a fragment remains of the Castle, and this apparently must soon fall to pieces. Much historical interest is attached to the ruins. During the reign of Henry I., in the year 1102, the castle was held by Robert de Belesme, Earl of Shrewsbury, a monster of cruelty, according to Lingard, and "whose delight was to feast his eyes with the contortions of the victims, men and women, whom he had ordered to be impaled." Bridgenorth was besieged, fell, and De Belesme took to flight, as his custom was, and afterwards capitulated at Shrewsbury. His estates were confiscated, but he was permitted to retire to Normandy, where he joined the Duke Robert, and deserting him in the battle of Tenchbray, by withdrawing his troops, added treachery to a name already stained by cruelty, rapacity, and cowardice.

In 1155 Henry II. set to work to reduce the "dens of thieves," otherwise the numerous castles which were then the curse of England, and we read that 1100 of these dangerous strongholds fell before his troops. Hugh de Mortimer, according to Grafton, "a very prowde and hawtie man, fortified dyvers townes and holdes against the king as Glocester, Worcester, and the Castle of Bridgenorth" to which in consequence, Henry laid siege. Here his life was saved by Hubert de St. Clare who seeing an arrow flying with deadly aim, stepped forward and received in his own heart the shaft which otherwise would have killed his king. Little is recorded of its later history, but Leland notes that "the walls of it be of great height," and "I count the castle to be more in compasse than the third part of the town." In the wars of Charles I. and the republicans, Bridgenorth espoused the cause of that unhappy king—it was taken and nearly demolished by the Parliamentarians. The tower owes its leaning condition to having been undermined by their forces during the siege.

The Church of St. Mary Magdalene is supposed to have

been built upon the site of an ancient chapel that stood within the castle walls. Leland says, "It was first made by Robert de Belesmo for a chappel onely for the castle, and he endowed it with landes, and upon that this chappel was established in the castle; there was a like foundation made at Quateford, a chappel of St. Mary Magdelene, by Robert de Belesmo, Earl of Schrobbesbury, at the desire of his wife that made vow thereof in the tempest of the sea."*

Bridgenorth stands on Bunter rock, which is exposed in a good section, and has been excavated in several places for cellars and foundations of houses. It is of peculiar brick red colour like the Bromesberrow Sandstone.

Among the first of the geological phenomena to observe around Bridgenorth are the fine sections of *Drifts* exposed by the cuttings of the Severn Valley Railway, and in order to investigate their history well, the course of the river should be followed upwards, by picturesque cliffs of Bunter and Permian Sandstone, to Coalbrook Dale and Buildwas. The Buildwas and Strethill beds were extraordinarily rich in shells, and in the drift at the latter locality, Mr. Maw found thirty-five species of marine shells, four Cirripedes, an Annelid and a sponge. Among the shells were Ostrea edulis, Cyprina Islandica, Astarte borealis, Tellina Balthica, Teredo Norvegica, Litorina, Aporrhais, Purpura lapillus, Buccinum undatum, Fusus antiquus. In all probability these drifts were deposited in a hollow dammed up by a barrier of rock which ran between Benthall Edge on the west and Lincoln Hill on the east. The valley of Ironbridge is now shut in by hills rising 500 feet above the Severn and its drifts, which now lie at a height of upwards of 200 feet, and once extended across the valley, and helped by their silting to form a barrier to the gorge. Nor are these the highest drift beds in the country, Mr. Maw pointed out to me similar drift sands and shingles 250 feet above the stratified and nearly horizontal sands on the summit of Strethill.† From Ironbridge the Severn descends rapidly

* Itinerary, iv., 182—6.

† See Maw on Severn Valley Drift, Quart. Journ. Geol. Soc., vol. xx., May, 1864.

through a gorge, and the drift beds are denuded in the narrow valley through which it runs to Bridgenorth. After the river escapes through the gorge below Bridgenorth the valley widens out into alluvial meadows, which once were probably lakes, and on the sides of these, the shell-bearing drifts rise in terraces on the flanks of the low hills that bound the river. I have myself found fragments of shells in the Bridgenorth gravels, and Mr. Maw obtained a few perfect specimens during the railway excavations.

Nor must we forget to direct attention to the large erratics which lie sometimes on the surface of the drift as if they were dropped there after its deposition, and which occur abundantly on the higher lands both west and east of Bridgenorth. At Worfield an old man informed me that he remembered "big stones all over the country before they broke them up for the roads." Blocks of grey granite may still be seen built into walls, and the site they travelled from is Cumberland. There is little doubt that the only way of accounting for the distribution of these erratics is by floating ice carrying these boulders during the great general, glacial, submergence. Mr. Maw directed my attention to a mass of granite drift with blocks of granite in it, on some high ground between his residence at Benthall Hall and Mount Wenlock. I saw no way of accounting for such isolated patches of granitic shingle save by the theory of stranded icebergs. The strongest advocate of the land-ice theory could hardly expect a "mer de glace" to extend from Cumberland to Bridgenorth.

Near Bridgenorth the relative positions of the Permian beds and the Coal-measures may be seen between Oldbury and the Hundred House, but there is a fault along the Severn which throws down the Permian rocks. In walking westward from Bridgenorth to the Leasowes, we pass over the Bunter, over Permian beds, Coal-measures, and on to Old Red. Another pleasant and instructive walk with the hammer and pencil, is from Bridgenorth by the Hermitage, along the conglomerate, at the base of the Lower Keuper Sandstones (Waterstones), by Quatford Castle to Quatford. Here we come on to Bunter beds

which dip from the river under the conglomerates, and crossing from Quatford to Quat by Dudmaston, we come upon the Lower Permian Grits as is soon seen by the change in the character of the soil. The cave in the rock of the Hermitage is said to have been the habitation of the brother of King Athelstan, and the country round called "Morfe" in the time of Leland, was "a forest or chace having deer." It also seems to have been the burial-place of distinguished warriors after some great battle, for it is recorded that "on Morfe are five tumuli in quincunx." In the middlemost, at about nine yards over, in the depth of one foot to the solid rock, was found only an iron shell of the size of a small egg, and supposed to be the boss of a sword, and in a hollow in the gravel some of the larger vertebræ and other human bones, as in the other tumuli.* At Quatford still stands a portion of the church founded at the desire of the wife of "Robert de Belesmo," and the Norman chancel arch is remarkable as being built of travertine, which, as I have already observed, was probably brought from Ribbesford.

It is recorded of the church of Quat when rebuilding in 1763, that it contained a piece of vellum nailed to an oak board, on which was a figure of Christ rising from the tomb, and that under the figure were the following lines:—

"Saynt Gregory and other popes
and byschops grantes sex and
twenty thousand zere of pardonz
thritti daies to alle that saies devou
telye kneling afor y^{s} ymage fife
paternosters, fyfe aves, and a Cred."

Over the head of the figure was—

"ihs is my lorde and lyff."
(Gough's Camden, vol. iii., p. 19.)

South of Quat is Higley, which lies on the Lower Permians in a singularly faulted district. The Coal-measures are faulted on the east, and we pass over them in going down to the Severn, while to the westward, at a place called "The Hind,"

* Phil. Transactions, No. 464, p. 27.

is an outlier of undenuded Permian rock. In a quarry at Higley, I saw what appeared to me to be silicified wood, but in all that district I never succeeded in obtaining a good Permian fossil, or of hearing of any one who ever did. At Stanley, near Higley, there were formerly coal works, but the beds were found to be so broken up and dislocated by the faults running eastward and westward from the Severn, that mining had to be abandoned. To the west of Higley is the exposition of Kinlet trap, and I have little doubt that this outburst is a continuation of the volcanic vent that poured forth the basalt of the Titterstone Clee into and over the coal-measures. The Old Red Sandstone is brought up in masses at Kinlet by the volcanic outbursts which poured forth the Trap rock on the Kinlet Hills.

Six or eight miles to the south of Kinlet, and about three miles S.E. of Cleobury Mortimer, is a very remarkable outlier of Permian breccia, known as Church Hill. It is over 900 feet in height, and is a puzzle to geologists. The Church Hill breccia is to all intents and purposes an *outlier* of Permian breccia, similar to those of the Clents, Warshill, and Stagbury Hill, which is immediately opposite to, but separated from it by six or seven miles of Coal-measures, and to the eastward by the Old Red. To the east of Church Hill and about two miles and a half distant, is the upcast of Silurian rock at Neen Sollers, and to the north, Old Red strata are faulted against and through the coal-measures. It is my impression that the centre of Church Hill is a trap rock, which is the real cause of the disturbance of the strata in this district, and that Permian broken and reaggregated rocks still cling to the uplifted igneous masses. But if this be the case, we must not lose sight of the fact that Church Hill reveals to us, that the Permian rocks were once deposited over a large area of country westward of the Abberley and Bridgenorth districts. I believe that they once extended above the now denuded Coal-measures, across the Old Red rocks over the sites where Cleobury Mortimer and Hopton Wallys now stand, to the Clee Hills on the west. The breccia of Church Hill consists of

often good-sized angular fragments of Permian rocks, and it has partaken of the dislocation to which the coal-measures have been subjected. The geology of this district is peculiar, as any lover of the science will find, who will take the trouble to investigate the points from the Upper Silurians of Neen Sollers, crossing the Old Red and Coal-measures to the outlier of Permians at Church Hill, and then by the Old Red of Heitington to the Permians of Stagbury. I may mention that the Brock Hill trap dyke which is seen in contact with Old Red at Shelsley Beauchamp on the Teme, is about seven miles directly south of Church Hill, and a line drawn from this dyke northwards to the igneous rocks of Kinlet, would almost pass under the breccias of Church Hill.

At Alveley there are quarries in the Lower Permians, near Shropshire Farm, and at Lane's quarry many remains of fossil plants have been found; they are in a very fragmentary state although they evidently belonged to trees of considerable size. They are regularly silicified, the vascular tissues being here and there filled up with sulphate of barytes. The plant stems which occur in these beds have been identified as similar to those of Allesley, near Coventry, and of the Rothliegende of Germany. The ironstone nodules at Alveley are remarkable, and look like cannon-balls, and are nearly as heavy. The *highest* beds of the Permian series in this part of England may be seen on travelling from Higley, near Bridgenorth, by Alveley to Enville. North-east of Alveley, higher beds come on at Coton, and the lower, plant-bearing, strata of Alveley may be traced across the valley to the escarpment or ridge at Coton, where they dip eastward, and are covered up by the crystalline conglomerate, which, in this district, rises into a bold eminence. The calcareous conglomerate of Coton is composed of pebbles and fragments derived from the Carboniferous Limestones, broken-up Permian rocks, and Millstone Grit, cemented together in a calcareous paste. It is best seen near Coton Hall to the westward. Between Coton and Enville it is burnt for lime, a necessity in the poor cold soils of Permian marls and sandstones. North-eastward of Coton is Tuck Hill

quarry, with a capping of conglomerate which differs from that seen at Coton, as it supports some broken-up sandstones. I imagine that it lies higher than the conglomerate at Coton, but it occupies a lower position than the upper breccias of Warshill, and those of Haffield and May Hill.

North of Tuck Hill the *Warshill breccias* come on at a place known as Rickthorn Hill, and here we find the so-called "Trappean Breccia," the only representative of the Permian system which occurs westwards, or in the Abberley and Malvern districts. This rock contains here and there trappean fragments, but the greater part of the breccia consists of *broken-up Permian Grits* re-cemented into a hard, well stratified mass, dipping away from the more ancient, upheaved deposits. These upper angular breccias, and thin sandstones and grits, are not strictly the highest beds of the Permian rocks in the West of England, for near Enville they are overlaid by strata which may be considered as the lower beds of the Magnesian series of Durham and Yorkshire, and of the Zechstein of Germany. These are the Upper Permian sandstones and marls of Enville, which are themselves overlaid by the Bunter Red Sandstone and the pebble beds of the Lower Trias. It is to Enville that the geologist must go, if he would understand the evidence and observations which induced Professor Ramsay to believe that fragments of some of the rocks imbedded in the upper breccias were borne by ice floating over the Permian seas.* Specimens from the breccias are exhibited in the Jermyn Street Museum in London, and one of the most characteristic is a fragment obtained from a place near Enville, and which has had the honour of obtaining a record in Sir Charles Lyell's "Principles of Geology."† The pebble is "of hard Cambrian Grit, with a smoothed surface, exhibiting parallel sets of striæ in more than one direction." Sir Charles goes on to say that he is fully satisfied that such fragments have been taken out of the breccia, and indicate a glacial period in Permian times. As far as my own experience goes, I have

* Ramsay, Quart. Geol. Journ., vol. ii., 1855.
† Ed. 11, p. 223.

been singularly unfortunate. I have travelled a great many miles to see these Permian erratics, but I never have seen *in situ*, in Permian breccias, "those masses of angular rock, some of them weighing more than half a ton, and lying confusedly in a red unstratified marl, like stones in a boulder drift, and in some cases polished, striated, and furrowed like erratic blocks in the moraine of a glacier, and which can be shown in some cases to have travelled from the parent rocks, thirty or more miles distant, and yet not to have lost their angular shape."*

I have seen Boulders, many of them of considerable size, which, on the Clents and in the country between Bridgenorth and Enville, are stained by the Permian marls, and, indeed, are sometimes intermingled with the Permian pebbles themselves; but I have attributed these boulders to the age of the Northern Drift, which stranded so many erratics on and amongst rocks of all ages, rather than to the action of drift during the Permian period. My experience, however, is not brought forward as throwing any doubt on the authenticity of the Permian boulders as found by Professor Ramsay. I record my own want of success in seeing such specimens *in situ*, as showing how advantageous it is for local observers to mark where such specimens occur in country places, as around Enville, inasmuch as the amateur, and wandering geologist, may make half a dozen pilgrimages to see such recorded phenomena and not see them. I have never seen an angular erratic in Permian breccia weighing half a hundredweight, much less "more than half a ton."

The Boulder Drift covers a large area between Bridgenorth and Wolverhampton. Rudge Heath is an excellent locality to see travelled blocks of granite from Cumberland, and greenstone masses from the north; Bushbury hill, near Wolverhampton, also is remarkable for the number of erratics lying against its north-western flank, the side facing the line of deposition of the Northern Drift. There are fossiliferous sands and gravels near Bushbury Hill which were excavated during the railway cuttings, and from which the Rev. Wm. Lister

* Lyell's Student's Elements, p. 372.

obtained a series of shells similar to those obtained by Mr. Maw near Buildwas, on the Severn. Among them were Astarte arctica, Cyprina Islandica, Nassa, Turritella, Purpura, and many others common to our British seas. I have observed one peculiarity as regards this sand and gravel, and fossiliferous drifts in several localities, as near Wolverhampton, near Shrewsbury, and in Yorkshire; it is that they often have large boulders lying immediately *above* them, or on their upper surfaces, as if the boulder erratics had been deposited after the accumulation of the shell-bearing sands and gravels. At Oxley Manor, north-west of Bushbury, a bed of Boulder clay overlies the sands and gravels, and has yielded some fragmentary shells, many of which I saw in the possession of Mr. Lister. Mr. Gwyn Jeffreys thought it not unlikely that these boulder clay shells may have been stranded by icebergs after traversing the glacial seas, it may be from the far north. These clays with shells require further investigation in this country. They occur west of Wolverhampton, and I believe overlie and are newer than the sand and gravels and their shells. At Acleton, eight miles south-west of Bushbury, the boulder clay yields Turritellæ and Cardia.

Hagley, "The British Tempe" of Thomson's Seasons, and associated in the poems of Pope, Shenstone, and Hammond with the famous Lord Lyttelton, lies at the western base of the Clent Hills. Hugh Miller visited Hagley, and the Leasowes, in 1845, and has left an elaborate description of what he saw, and what he thought, in his "First Impressions of England and its People." The Clent Hills rise on the southern side of the Dudley coal basin, the Coal measures being elevated on the north by the Trap rocks of Dudley and Rowley, which have also brought to the surface the well-known Upper Silurian rocks of Dudley and Walsall. In Hugh Miller's time the Clents were believed to be a range of Trap rocks, extending seven miles in length and rising to about 800 feet above the sea, and lying parallel to the Silurians of Dudley in their range. They are now known to consist of Permian rocks which nearly flank the Dudley coal-field, and at Barr, on the

eastern side of the Silurian upcast, they are thrown off from Wenlock and Woolhope strata. The Dudley coal-field and the Permian deposits rise out of the Lower New Red Sandstone, which occupies a rich undulating country capped in different localities with Northern Drift. Hagley village stands on the Lower New Red, but a section of the Permian rocks may be seen in Hagley Park below the Rectory. The conglomerates here are, I believe, the *lower* conglomerates which overlie the lowest red sandstones and marls of the Rothliegende. They are not so calcareous as those of Coton, and do not resemble the *upper* breccias. North of this section are beds which are probably higher in the series, and may be the equivalents of the Coton conglomerates north-west of Stourbridge.

Hagley village possesses a comfortable village inn where many a naturalist has taken his ease, and many a geologist has met with his "warmest welcome" "where'er his stages may have been," when he was rambling over the Clents. Hugh Miller "baited" there, drank cider, and fell in with an "old grey-headed man," "who was engaged by the wayside in sawing into slabs a large block of New Red Sandstone." He also met with a gardener who conducted him to the landscape which Thomson loved, and who showed him the temple dedicated to the memory of "a sublime poet" "and a good man," "who greatly loved, when living, this hollow retreat." Passing upwards to the hilly region of Hagley, we come upon the favourite haunts of Pope and Shenstone, and where the noble oaks on every side, which Shenstone so admired, particularly struck the Scotch geologist. South of Hagley wood is Shenstone's "various wild," "for Kenelm's fate renowned," where stands the curious old Church of dark red sandstone, said to mark the site of the murder of Kenelm, in the time of the Heptarchy, at the instigation of his sister Kendrida, who wished him out of the way of her own lover, who himself sought the Mercian throne. "Such," says Hugh Miller, "was the odour of sanctity which embalmed the memory of St. Kenelm, that there was no saint in the calendar on whose day it was more unsafe to do anything useful."

"The chapel received gifts in silver, and gifts in gold,"—"crowns" and "ceptres" and "chalysses." There grew up around it, mainly through the resort of pilgrims, a hamlet, which in the times of Edward I. contained a numerous population, and to which Henry III. granted an annual fair.

There is a section on the eastern flank of the hills near this old church of St. Kenelm, and below it, is a farm-house and a bridge over a small brook. By walking down the stream, Permian sandstones may be seen *in situ*. Above the church, on the road to the hill, we find bands of Permian "Cornstones," which might easily be mistaken for Old Red Cornstones. They have occasionally been quarried for lime. The Permian breccia caps the hill, but the beds are much weathered and broken up. The slabs of stone on the summit of the Clents, look as if they had once formed a cromlech, and consist of this Permian "cornstone" or middle conglomerate; probably they were quarried near at hand.

The prospect from the Clents is very varied. On one side we have the strange Coal country with its furnaces, chimneys, pit-fires, its innumerable dingy villages and endless smoke; while on the south we behold the Malverns and the Abberley Hills, and to the westward rise the Wrekin and the distant mountains of Wales. It is this side of the landscape that the poet Thomson describes from the hill above the Hall of Hagley.

Halesowen, the residence of Archdeacon Hone, was the place wherefrom Hugh Miller visited The Leasowes, "the patrimony which poor Shenstone converted into an exquisite poem, written on the green face of nature, with groves and thickets, cascades and lakes, urns, temples, and hermitages, for the characters." At the Inn too there he met with an English squire who offered him hospitality, and the only hospitality he appears to have met with throughout his English tour. The Poet's ideas, dreams, and efforts for the picturesque, as also those of the button-maker who succeeded him, are well told in Miller's "First Impressions," which were not written under favourable circumstances, with bad weather, dull, solitary inn-rooms, and failing health.

The Lower Permians or Rothliegende are quarried at Halesowen, at which place there appears a fault running through the Clents from the Dudley upheaval. This fault appears to have affected the Coal-measures in the Halesowen district, inasmuch as shafts which have lately been sunk for coal, show that the coal-measures have been denuded along a line of upheaval. My friend, the Rev. Mr. Thompson, of Cradley, has seen remains of Permian plants in these rocks of Halesowen.

Another example of Permian rocks skirting the old coast line of the Straits of Malvern, is Warshill Camp, near Kidderminster. I visited this district in company with Mr. George Roberts, who pointed out to me the singular situation of the Old Red Cornstone, and the Permian "Cornstone" within a short distance of each other. The Permian beds are seen on Warshill on the east, whereas on the west, at a place called Hall's Barn, the Lower Old Red Cornstones appear with their characteristic fish plates of Pteraspis and Cephalaspis. This is a notable spot for any geologist to visit. Measured across a gullet these two bands of rocks, representing two great systems in geology, the Devonian and the Permian, are separated only by about 150 feet. Yet they are divided in geological history by the whole of the great Carboniferous series, and not one animal or plant is common to both. Would that we knew more of the history those two rocky bands of strata might tell us, if they could compare notes of the past across that little dingle.

At Hoarstone Farm the Permian grits and sandstones are seen dipping into the Camp Hill and underlie the breccia. A quarry at the brick-kilns exhibits a breccia interstratified with grits and sandstones. It was after having examined the Permian sections in the neighbourhood of Alveley and Warshill, that I became satisfied that the upper breccias of the Abberley Hills*—along the flanks of the Malverns as at Howler's

* It may be useful to remind the amateur that the term "upper" here refers to upper strata of the *Lower Permians* in the above districts. Higher breccias come on to the East.

Heath and Haffield, and again at May Hill—are not composed of *foreign erratics*, but consist principally of broken-up fragments of the Permian grit, which I have called "Warshill grit," in numerous lectures and public addresses, re-aggregated and cemented together. Here and there, as we might expect, fragments of the local rocks, against which these Permian breccias fringe, occur in the conglomerates, but the main elements are Warshill grits.

From Stourport the explorer should visit Redstone Cliff, a fine escarpment of Lower New Red Sandstone rising from the river. It has yielded to the botanist the rare Geranium phæum and the Saxifraga granulata. From thence he should ascend Stagbury Hill, an eminence of Permian rocks, which attains a height of more than 700 feet. The breccia is like that of Warshill, and on the western side of the hill, there is an exposure of Permian sandstone and grit, dipping eastward. A deep ravine occupied by a narrow strip of Carboniferous rocks, faulted on edge, intervenes between this Permian hill and the woods on Old Red Sandstone beyond. Fragments of coal lie about here and there where the ground was worked, but the beds are too much faulted and broken to pay for mining. Stagbury Hill commands a fine view of other Permian rocks for those who like to read off the physical geology of the country. We may see Enville, Warshill, and the Clents, the hills that flank the Abberley range, viz., the Berrow Hill and Woodbury, while we bear in mind that the same breccia is now known to have once flanked the hill of North Malvern, and occurs on the outlier of Church Hill to the west.

There is a remarkable exposition of Permian conglomerate at Rosebury Rock, forming the southern bank of the river Teme, a short distance below Knightsford bridge. North-west of this is the Silurian ridge of Ankerdine, and the Permian breccia of Rosebury rests against faulted and upheaved Old Red Sandstone. The fragments in the conglomerate are of all sizes below two feet in diameter, and worn at the edges and angles. I have searched in vain for any evidence of the accumulation of fragments of the Silurian rocks of Ankerdine

in this breccia, although those hills are so close at hand. The Teme here flows through a line of fracture, and divides the faulted rocks. The re-aggregated Permian breccias extend northwards from Rosebury rock by Ankerdine Hill, where they rest against Upper Llandovery, by Berrow Hill, where they flank Old Red Sandstone, and on the summit of which the conglomerate crops out, to Woodbury Hill. Here they abut against Wenlock rocks on to the slopes of the Abberley Hills, where they flank Upper Silurian strata, thus everywhere ranging along an ancient line of fault, and everywhere containing the Warshill grits. The history of these singular beds of stratified angular fragments is highly interesting, and may be well investigated from Knightsford Bridge. Rosebury Rock itself is a picturesque object for the painter, and we sadly want illustrations of our most remarkable geological phenomena. It is beautifully wooded, and with the Teme rolling rapidly at its base, affords a scene worthy of the pencil of one who is at the same time an artist and a geologist.

The Permian breccias, though now they are nearly all denuded, were laid down against the North Malverns, for a little patch with its glazed pebbles still remains in a hollow in the syenitic gneiss in Cowley Park. Again, when excavating, lately, in the great quarries on the northern flank of the North Hill, Great Malvern, the breccia was exposed with its peculiar purplish red pasty deposit and its shiny pebbles. The pebbles are small but are mostly of Warshill rock. I saw here an angular block which the workmen declared came from the "purple ground" against the quarry. It was of a hard silicious rock, certainly no Malvern rock, and weighed several hundred weight. It was the occurrence of masses similar to this great fragment, which induced Professor Ramsay to attribute their presence in the breccia to the action of floating ice stranding and melting with its burden along a coast during the Permian period. But it is difficult to separate these erratics from those of the true Glacial boulder drift which has I know in some instances, as at Enville and at the Clents, deposited

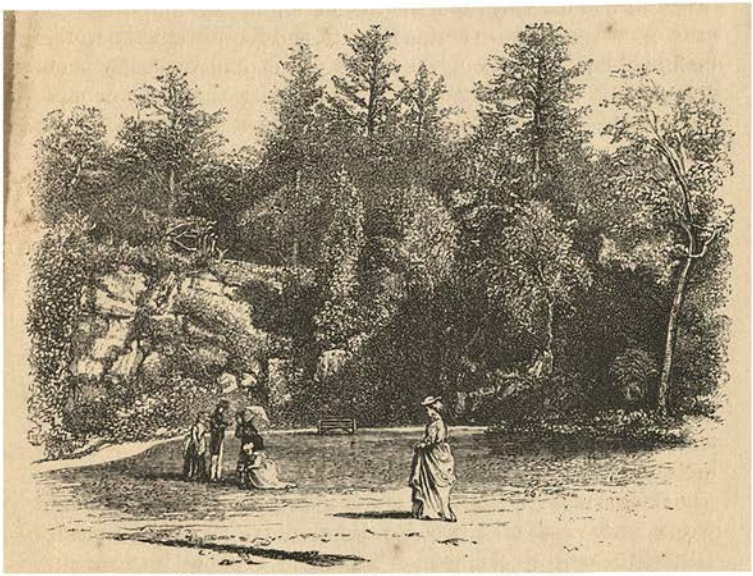
glacial boulder drift right against and among the Permian breccias.

When excavations were being made several years ago against that part of the Malvern range where the Imperial Hotel now stands, I was informed that some large bones had been discovered in digging out the foundation of the building. I at once proceeded to examine the site, and found that the workmen had cut into an *old glacial till* which had evidently been deposited in and against the Permian strata that once flanked this part of the old coast-line. The till consisted of stiff purple clay and in it were some glazed pebbles, northern drift pebbles, and some angular boulders, one of which is a distant erratic probably from Wales. It is now in the Malvern Museum at the College. The till yielded the remains of the Mammoth and Rhinoceros tichorinus, the teeth and some of the bones of which may also be seen at the Museum. I mention the occurrence of this glacial till with Permian pebbles to show how puzzling are these boulders and breccias when found together.

No Permian conglomerate or breccia appears along the eastern flanks of the Malverns until we pass the southern extremity of the chain, and arrive at the south-western end of the Chase-end Hill. Here it abuts against the Malvern gneissic rocks, and rises in a wooded knoll north of Bromesberrow Place, the seat of Mr. Osman Ricardo. It is to be seen dipping away from the Llandovery rock of Howler's Heath in the lane between the Chase-end Hill and Bromesberrow Rectory, and just beyond the farm-house known as Toney's Farm, is a section where good-sized fragments of Permian grit may be obtained from a matrix of red pasty rock. It is seen dipping away from Woolhope limestone, N.W. of Toney's Farm; Wenlock limestone, near Clincher's Mill; and Old Red Sandstone at Haffield Camp. The Bunter Sandstone of Bromesberrow rests unconformably on the uplifted Permian breccia, and is laid down at a much lower angle. It is probable that the Bunter beds once overlapped the Permian breccia, if we may judge from the position of those rocks and the overlying Waterstones

against the gneiss axis of the Malvern range in the wood behind the Hawthorns, the residence of Mr. Winnall, well known for his hospitality to numerous Naturalists who visit the Southern Malverns.

A good section of Permian breccia occurs below Haffield



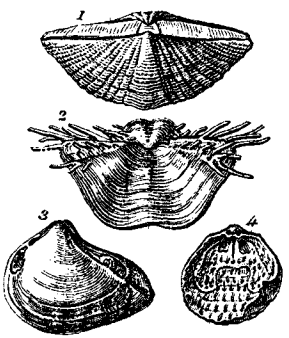
PERMIAN BRECCIA AT HAFFIELD, NEAR LEDBURY.

Camp, three miles S. of Ledbury, the residence of my friend Dr. Henry. A fine escarpment faces the Hall door; and the stratified condition of the Conglomerate is well displayed, dipping eastward under the Bunter beds, which were lately exposed at the base of the hill between the Dick House Farm and the entrance Lodge, a pit being opened for gravel. In this hollow is a mass of Northern Drift, and, on quarrying the gravel for road purposes, the rocky bottom of the old sea bed of the ancient Severn straits was exposed to view. It consists of Bunter sandstone dipping away at a low angle from the hill, and is grooved and scooped, across the line of dip, into

irregular ridges. On this old sea bed, surrounded by other smaller fragments of local rocks, was a great block of Wenlock limestone, grooved and scratched on one side. It was covered up by a mass of Northern Drift pebbles, among which we found Lias gryphites and a few chalk flints. Haffield Camp is one of several earth-works which, in olden times, were numerous at the south-western end of the Malvern chain, and appear to have run from Gadbury Camp and Eldersfield, by the Conygree Hill of Bromesberrow and Haffield Camp, to the large fortress of the Wall Hills, west of Ledbury. The camp at Haffield is surrounded by a steep bank and fosse, and is about 300 yards long by 200 in breadth. Near the summit, on the eastern side, there are openings where stone has been raised, and all the fragments I could find therein were, without exception, angular and sub-angular fragments of Permian grit. Here and there are pieces of Trap rock, but they are by no means common, and I have often speculated whether, in this district, there may not have been a series of Trap bosses injected along the fissures of the ancient line of fault, over which the Permian rocks were laid down, both Traps and Permians being again upheaved and broken up by the later earth movements which affected all the strata along this line of fault. One point with regard to the angular breccias in this district is still unexplained, viz., *the glaze* upon the angular fragments. In Scotland and Germany, we find proofs, in the presence of ash beds and bedded lavas, that the Lower Permian period was one of great volcanic activity; while in the Silurian districts we observe these rocks generally ranged and upheaved along a line of fault. Earthquake action was evidently rife along these lines of dislocation, in many localities, in later periods, and it is possible that sulphurous and volcanic vapours emanated along this line which gave the glaze to the fragments in the breccias. The rocks, too, are deeply stained with peroxide of iron, and the celebrated hæmatite iron ores are now generally believed to be mineral segregations from Permian waters.

The Permian breccias were not known in the neighbourhood of May Hill until 1870, when in company with my friend Captain Price of Tibberton Court, Gloucestershire, I discovered them resting against Upper Silurian rocks, between Newent's Wood, which is on Old Red Sandstone, and Judge's Lane and the Ploddy House, where are seen the Bunters and Waterstones of the Trias. They dip at a high angle from the Silurian rocks of Jordan's Wood, and are immediately overlaid by Bunter red sandstones, which also dip

PERMIAN SHELLS.



1, Spirifer alatus, Schl. 2, Productus horridus, Sow. 3, Schizodus (Axinus) obscurus, Sow. 4, Strophalosia lamellosa, Geinitz. (All from the county of Durham. These species, except, perhaps, the Schizodus, are equally common in Germany and Britain.)

under the Waterstones of the plain, and are unconformable to the breccia. The Permian pebbles in this neighbourhood are precisely similar to those of Haffield and other places on the opposite shores of the Malverns, they have the same glaze, and when broken are seen to consist of "Warshill grit." Captain Price has since traced these breccias, southward of the locality where we first found them by Lynes Place and the Byfords. Here, as at Malvern, they run along a line of fault.

ORGANIC REMAINS OF THE PERMIAN ROCKS.

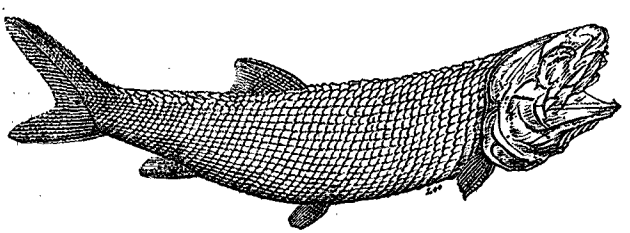
The Fossils of the Permian rocks in the parts of England described in this chapter, consist only of a few plants, and it

is not until we find this formation thickening on its northward and eastward strike that fossils become at all numerous. The total known fauna of the Permian series of Great Britain numbers about 150 species, of which 77 are Mollusca. The Lower Permian strata are characterised by their silicified plants such as Psaronius, the trunks of tree-ferns, Lepidodendron common also to the coal, Asterophyllites also a coal plant, several species of Ferns and Walchias, Noeggerathia, and Conifers allied to Araucaria.

In the Middle Permians of Durham numbers of beautiful specimens of fossil fishes have been found; they have been described by Sir Philip Egerton in a monograph by Prof. King, and in all, the heterocercal tail predominates. The genera are Palæoniscus, Pygopterus, Acanthodus, Cœlacanthus and Platysomus.

Reptilian remains have been found in the same marl slates near Durham. Lingulæ, Producti, Strophalosia, and Spiriferæ of peculiar forms, occur in the yellow magnesian limestone with Schizodus, Arca and Avicula; spiral Univalves are rare.

The Upper Permians of Cumberland have a thin limestone bed containing fossils similar to those of the Middle Permians, among them are the Camaraphoria of Prof. King.



PALÆONISCUS AND HETEROCERCAL TAIL, FROM THE KUPFER-SCHIEFER OF MANSFELD IN GERMANY.

"To Thee, whose Temple is all space,
Whose Altar, earth, sea, skies,
One chorus let all Being raise,
All Nature's incense rise."

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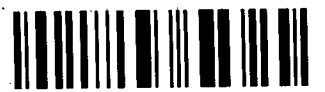
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